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NOTE.

THE authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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ERRATA.

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,, 3	16	40	*for* "work" *read* "works."

I.—A Discussion of the Theorems of Lambert and Adams on Motion in Elliptic and Hyperbolic Orbits.

By L. V. Meadowcroft, B.A., M.Sc.

(Communicated by Professor Sydney Chapman, M.A., D.Sc., F.R.S.)
(Read Dec. 2nd, 1919. Received for Publication, Dec. 29th, 1919.)

The theorem of Lambert* on the motion of a planet in an elliptic orbit is usually enunciated as follows :—

"If t is the time of describing any arc P_1P_2 of an ellipse, and k is the chord of the arc, then $nt = (\phi_1 - \sin\ \phi_1) - (\phi_2 - \sin\ \phi_2)$, where $\sin \frac{1}{2}\phi_1 = \frac{1}{2}\sqrt{\frac{r_1 + r_2 + k}{a}}$, $\sin \frac{1}{2}\phi_2 = \frac{1}{2}\sqrt{\frac{r_1 + r_2 - k}{a}}$"

r_1, r_2 are the focal distances of the points P_1, P_2, a is the semi-major axis of the ellipse and n the mean angular velocity about the focus.

The most elegant proof is that due to J. C. Adams,† which will be reproduced here in view of the interesting geometrical results to which it gives rise.

Let μ_1, μ_2 be the eccentric anomalies of P_1, P_2,

$$\therefore k^2 = a^2(\cos \mu_1 - \cos \mu_2)^2 + a^2(1 - e^2)(\sin \mu_1 - \sin \mu_2)^2$$

$$= 4a^2 \sin^2 \tfrac{1}{2}(\mu_1 - \mu_2)\left[1 - e^2 \cos^2 \tfrac{1}{2}(\mu_1 + \mu_2)\right] \quad . \quad . \quad . \quad . \quad (1),$$

$$r_1 + r_2 = 2a - ae \cos \mu_1 - ae \cos \mu_2$$
$$= 2a\left[1 - e \cos \tfrac{1}{2}(\mu_1 + \mu_2) \cos \tfrac{1}{2}(\mu_1 - \mu_2)\right] \quad . \quad . \quad . \quad (2),$$

$$nt = \mu_1 - \mu_2 - e(\sin \mu_1 - \sin \mu_2)$$
$$= (\mu_1 - \mu_2) - 2e \cos \tfrac{1}{2}(\mu_1 + \mu_2) \sin \tfrac{1}{2}(\mu_1 - \mu_2) \quad . \quad . \quad . \quad (3).$$

Since a, and therefore n, are given, it follows from (1), (2) and (3) that $r_1 + r_2$, k and t are functions of the two quantities $\mu_1 - \mu_2$ and $e \cos \frac{1}{2}(\mu_1 + \mu_2)$.

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* "Insigniores orbitæ cometarum proprietates," 1761.
† *British Association Report*, 1877, or Collected Works, p. 410.

Let $\mu_1 - \mu_2 = 2\alpha$, $e \cos \frac{1}{2}(\mu_1 + \mu_2) = \cos \beta$ . . . . (4),

$\therefore k = 2a \sin \alpha \sin \beta$ . . . . . (5),

$r_1 + r_2 + k = 2a\,[1 - \cos(\beta + \alpha)]$ . . . . . (6),

$r_1 + r_2 - k = 2a\,[1 - \cos(\beta - \alpha)]$ . . . . . (7),

$nt = 2\alpha - 2 \sin \alpha \cos \beta$ . . . . . (8).

If now we put $\beta + \alpha = \phi_1$, $\beta - \alpha = \phi_2$, the equations (6) and (7) lead to the required expressions for $\sin \frac{1}{2}\phi_1$, $\sin \frac{1}{2}\phi_2$, whilst (8) gives

$$nt = [\beta + \alpha - \sin(\beta + \alpha)] - [(\beta - \alpha) - \sin(\beta - \alpha)]$$
$$= (\phi_1 - \sin \phi_1) - (\phi_2 - \sin \phi_2)$$

In the figure Q_1, Q_2 are the points on the auxiliary circle which correspond to the points P_1, P_2 on the ellipse, and N_1, N_2 are the feet of the corresponding ordinates. Then $\angle ACQ_1 = \mu_1$, $\angle ACQ_2 = \mu_2$ and $2\alpha = -\angle Q_1CQ_2$

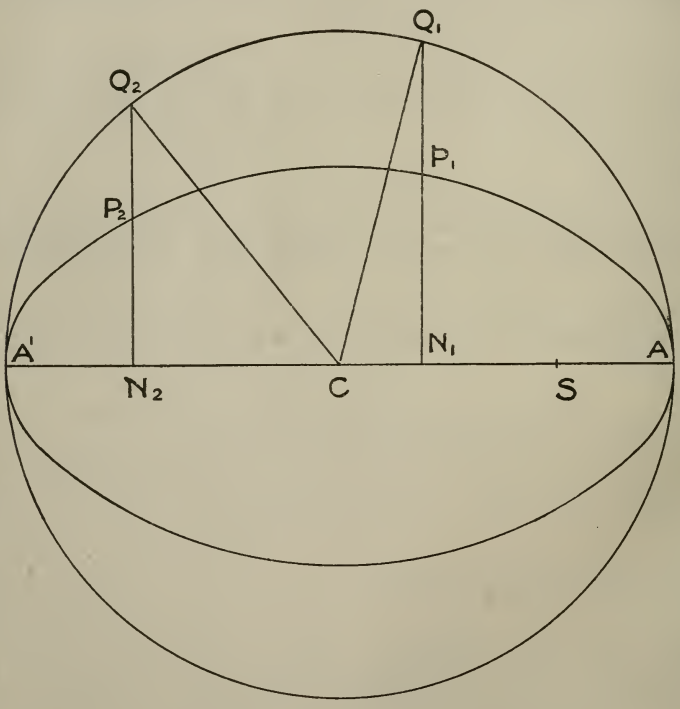


Fig. 1.

Now $ae \cos \frac{1}{2}(\mu_1 + \mu_2)$
$= e.\ CN$, if N is the foot of the ordinate drawn from Q, the middle point of Q_1Q_2. Let P be the corresponding point on the ellipse and r its focal distance. Thus $a \cos \beta = e.\ CN$, by (4), and in order to obtain a geometrical representation for β it is necessary to tranform

the right hand side of this equation so that e disappears. Now in the ellipse $r = a - e.\ CN$ or $e.\ CN = a - r$. Now take a point N' on CA such that $CN' = a - r = e.\ CN$, and let μ' be the eccentric angle of the corresponding point P' on the ellipse. Then clearly $\mu' = \beta$. Hence Adams' proof leads at once to a simple construction for α and β. To construct $\beta + \alpha$ and $\beta - \alpha$ (or ϕ_1 and ϕ_2) let Q' correspond on the auxiliary circle to P' on the ellipse, and take two points Q'_1 and Q'_2 on opposite sides of Q' and such that $\angle Q'_1CQ' = \angle Q'CQ'_2 = \frac{1}{2} \angle Q_1CQ_2$. Then the angles ACQ'_1 and ACQ'_2 (μ'_1 and μ'_2 say) are equal to ϕ_1 and ϕ_2.

These results suggest that an independent proof of the theorem may be given, based on geometrical considerations. Let P, P'_1, P'_2 be constructed as above. Then with the same notation as before we have $r_1 + r_2 = 2a - ae \cos \mu_1 - ae \cos \mu_2$.

$$\begin{aligned}
&= 2a - 2\ ae \cos \tfrac{1}{2}(\mu_1 + \mu_2) \cos \tfrac{1}{2}(\mu_1 - \mu_2) \\
&= 2a - 2\ CN' \cos \tfrac{1}{2}(\mu'_1 - \mu'_2) \\
&= 2a - 2\ a \cos \tfrac{1}{2}(\mu'_1 + \mu'_2) \cos \tfrac{1}{2}(\mu'_1 - \mu'_2) \\
&= 2a - a \cos \mu'_1 - a \cos \mu'_2 \\
&= 2a - CN'_1 - CN'_2 \\
&= AN'_1 + AN'_2 \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).
\end{aligned}$$

$$\begin{aligned}
\text{Again } k^2 &= 4a^2 \sin^2 \tfrac{1}{2}(\mu_1 - \mu_2)[1 - e^2 \cos^2 \tfrac{1}{2}(\mu_1 + \mu_2)] \\
&= 4a^2 \sin^2 \tfrac{1}{2}(\mu'_1 - \mu'_2) \sin^2 \tfrac{1}{2}(\mu'_1 + \mu'_2) \\
\therefore k &= 2a \sin \tfrac{1}{2}(\mu'_1 - \mu'_2) \sin \tfrac{1}{2}(\mu'_1 + \mu'_2) \\
&= a \cos \mu'_2 - a \cos \mu'_1 \\
&= N'_1 N'_2 \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10).
\end{aligned}$$

Hence, from (9) and (10),

$$\tfrac{1}{2}\sqrt{\frac{r_1 + r_2 + k}{a}} = \sin \tfrac{1}{2} \mu'_1 = \sin \tfrac{1}{2} \phi_1, \quad \tfrac{1}{2}\sqrt{\frac{r_1 + r_2 - k}{a}} = \sin \tfrac{1}{2} \mu'_2 = \sin \tfrac{1}{2} \phi_2.$$

$$\begin{aligned}
\text{Also } nt &= (\mu_1 - \mu_2) - e(\sin \mu_1 - \sin \mu_2) \\
&= (\phi_1 - \phi_2) - 2\ e \sin \tfrac{1}{2}(\mu_1 - \mu_2) \cos \tfrac{1}{2}(\mu_1 + \mu_2) \\
&= (\phi_1 - \phi_2) - 2 \sin \tfrac{1}{2}(\phi_1 - \phi_2) \cos \tfrac{1}{2}(\phi_1 + \phi_2) \\
&= (\phi_1 - \sin \phi_1) - (\phi_2 - \sin \phi_2).
\end{aligned}$$

Although very different in form from the proof given by Adams the preceding proof is not very different in substance, depending, as it does, on expressing $r + r'$, k and nt in terms of $\mu_1 - \mu_2$ and $e \cos \frac{1}{2}(\mu_1 + \mu_2)$. It is, however, of some interest as placing the matter on a definitely geometrical basis and for the immediate purpose for which it is here used appears to be superior to the geometrical proofs hitherto given *cf.* C. Taylor's "Ancient and Modern Geometry of Conics," page 241.

Similar considerations may be applied to obtain corresponding results for the hyperbola, but the results are necessarily more complicated as the representation of points on the curve by means of a single parameter is not of so simple a character as in the ellipse. If the equation of a hyperbola is $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ the co-ordinates of any point can be represented by a single parameter, μ, by the relations $x = a \cosh \mu$, $y = b \sinh \mu$. If, in the figure, P is the point (x, y), corresponding to the parameter μ, then $CN = a \cosh \mu$, $PN = b \sinh \mu$, and it is easily shown that the area of the sector CPA is equal to $\frac{1}{2} abu$.

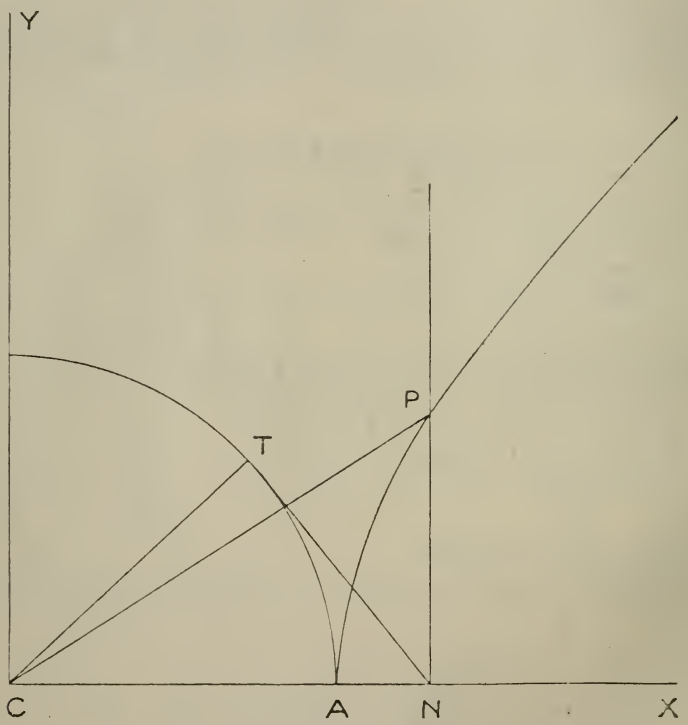


Fig. 2.

Adams'* theorem for the hyperbola may be enunciated as follows :— "If t is the time of describing any arc P_1P_2 of a hyperbola, and k is the chord of the arc, then $t\sqrt{\frac{\mu}{a^3}} = -\phi_1 + \phi_2 + \sinh \phi_1 - \sinh \phi_2$, where $\sinh \frac{1}{2}\phi_1 = \frac{1}{2}\sqrt{\frac{r_1 + r_2 + k}{a}}$, $\sinh \frac{1}{2}\phi_2 = \frac{1}{2}\sqrt{\frac{r_1 + r_2 - k}{a}}$"

**British Association Report*, 1877, or Collected Works, p. 410.

r_1 and r_2 are the focal distances of P_1, P_2, a is the semi-transverse axis, and μ is the acceleration at unit distance.

As before, let μ_1, μ_2 denote the parameters of P_1, P_2.

Then $r_1 + r_2 = ae \cosh \mu_1 + ae \cosh \mu_2 - 2a$

$= 2\, ae \cosh \frac{1}{2}(\mu_1 + \mu_2) \cosh \frac{1}{2}(\mu_1 - \mu_2) - 2a.$

Now let P be the point whose parameter is $\frac{1}{2}(\mu_1 + \mu_2)$ and N the foot of the corresponding ordinate. P will not now be the middle point of P_1P_2.

$\therefore r_1 + r_2 = 2\, e.\, CN \cosh \frac{1}{2}(\mu_1 - \mu_2) - 2a.$

Let N' be taken on the axis of x so that $CN' = a + r = a + e.\, CN - a = e.\, CN$.

$\therefore r_1 + r_2 = 2\, CN' \cosh \frac{1}{2}(\mu_1 - \mu_2) - 2a.$

If P'_1, P'_2 are taken on opposite sides of P so that their parameters μ'_1, μ'_2 satisfy the relations $\mu'_1 + \mu'_2 = 2\mu'$, $\mu'_1 - \mu'_2 = \mu_1 - \mu_2$, we easily find $r_1 + r_2 = AN'_1 + AN'_2$, ... (11)

N'_1, N'_2 being the feet of the ordinates from P'_1, P'_2,

and $k = N'_1 N'_2$ . . . . . (12)

$$\therefore \tfrac{1}{2}\sqrt{\frac{r_1 + r_2 + k}{a}} = \tfrac{1}{2}\sqrt{\frac{2AN'_1}{a}} = \tfrac{1}{2}\sqrt{2(\cosh \mu'_1 - 1)} = \sinh \tfrac{1}{2}\mu'_1 = \sinh \tfrac{1}{2}\phi_1,$$

and similarly $\frac{1}{2}\sqrt{\frac{r_1 + r_2 - k}{a}} = \sinh \frac{1}{2}\mu'_2 = \sinh \frac{1}{2}\phi_2$.

Hence μ'_1, μ'_2 are geometrical representations of ϕ_1, ϕ_2.

Now $t\sqrt{\frac{\mu}{a^3}} = -\mu_1 + \mu_2 + e \sinh \mu_1 - e \sinh \mu_2$*.

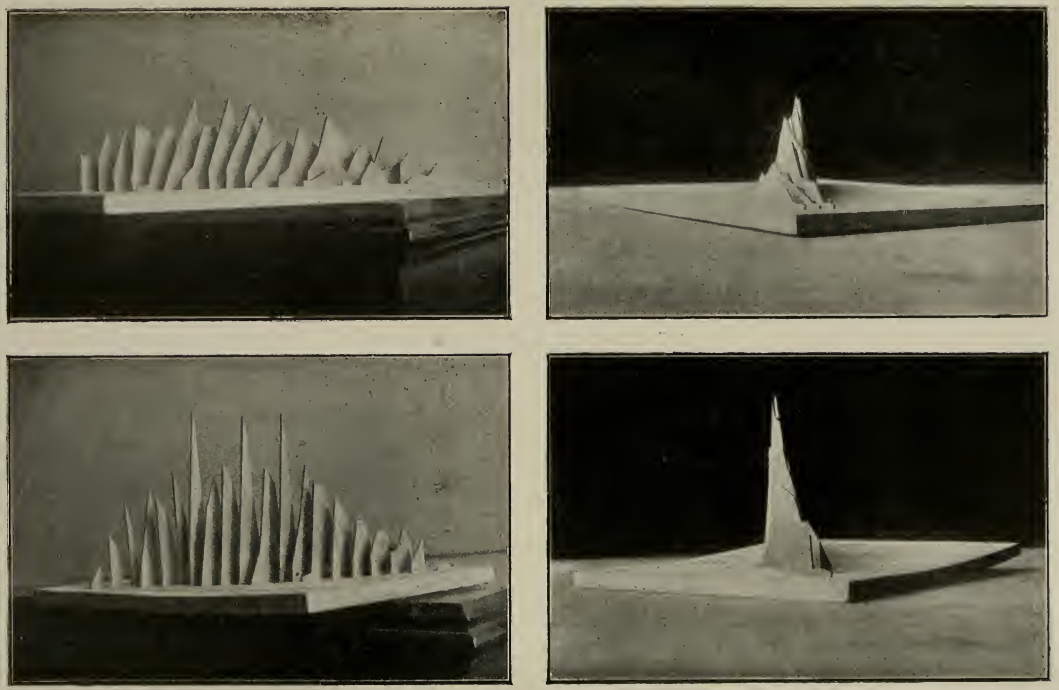
$= -\phi_1 + \phi_2 + \sinh \phi_1 - \sinh \phi_2$, on reduction.

That the analogy between the two cases is complete will be more fully appreciated when it is recollected that in the case of the ellipse, μ, besides denoting the angle ACQ, is also a measure of the sectorial area ACP. In fact the area ACP is equal to $\frac{1}{2}abu$, both in the ellipse and hyperbola. In the case of the ellipse the parameter of P is chosen half way between those of P_1 and P_2 and those of P'_1 P'_2 are so chosen that $\mu'_1 - \mu'_2 = \mu_1 - \mu_2$, $\mu'_1 + \mu'_2 = 2\mu'$.

* Routh's "Dynamics of a Particle," p. 226.

Fig. 1. Distribution of Length and Width.
A. Side view. B. End view.

A. B.



A. B.

Fig. 2. Distribution of Length and Depth.
A. Side view. B. End view.

II.—Morphogenesis of Brachiopoda.
I.—*Reticularia lineata* (Martin), Carboniferous Limestone.

By W. E. Alkins, M.Sc.

(Communicated by Dr. George Hickling, F.G.S.)
(Read December 2nd, 1919. Received for publication February 17th, 1920.)

Introduction.

In view of the great amount of biometric research that has been carried out during the last few years, it is somewhat surprising that very few investigations along such lines deal with Brachiopoda. The group is represented at the present time by rather less than a hundred and forty species, few of which occur in conditions such as would make them accessible in sufficient numbers for purposes of measurement; but brachiopods, except in the Tertiary rocks, constitute one of the most abundant and most important groups of fossils. Interesting to the zoologist not merely on account of the great age of the group, but also by reason of the extreme variability often exhibited within a single species, and of the prevalence of the phenomenon of heterogenetic homœomorphy, they are of the highest importance to the stratigrapher, since they occur almost world-wide, and frequently in greater abundance than any other group. Hence an enquiry into the variation and growth of a number of species may be of some interest.

Previous Research.

Quantitative studies of variation in certain species of fossil Brachiopoda have been published by Cumings and Mauck (1), by Day (2), and by Mook (3). The first-named authors studied *Platystrophia lynx* from the Upper Ordovician rocks at Vevay, Indiana (Switzerland Co.). The data taken for study were: Ratio of width to length of shell; ratio of depth to breadth of sinus; number of plications on ventral valve; number of plications on dorsal valve; number of plications in sinus; number of plications on fold. In the case of each of these quantities a fairly regular, though slightly asymmetric, distribution curve was

obtained; each rose abruptly, and fell off rather less abruptly, showing a certain correlation of the different variants. The correlation between number of plications in the sinus and number of plications on the whole valve, stated in a precise form by Hall, was found to be approximate rather than precise. Extreme forms were small in size, and conversely forms near the modes were large and robust. Finally, there was absolutely no character or combination of characters that could be relied upon to separate any large collection into distinct species, though several such species or varieties had been described; these forms to a limited extent differed in range.

No actual measurements were published. It is perhaps open to criticism that the whole series of shells was not taken from a carefully restricted area.

Day measured a thousand examples of *Reticularia lineata* (Martin) from "one spot in the limestone near Peakshill Farm, Rushup Edge Valley, Castleton." Remarkable variation in the form of individual shells was found, but distribution curves for the ratios $\frac{\text{Length}}{\text{Breadth}}$ and $\frac{\text{Length}}{\text{Depth}}$ gave no indication of the presence of two or more forms. Each of the ratios investigated was found to decrease as the shells increased in size, and the degree of correlation between variation in breadth and variation in depth was found to be equal to about one fifth of the whole variation; apart from this, the variations in breadth and depth occurred quite independently of one another.

Again, no detailed measurements were published. The variation in the $\frac{\text{Length}}{\text{Breadth}}$ and $\frac{\text{Length}}{\text{Depth}}$ ratios as the shells increase in size was only indicated qualitatively, without any attempt at a quantitative treatment. Fortunately Day's series of shells is preserved in the Manchester Museum, and the writer has submitted them to the method of investigation described below.

Mook investigated five mutations of *Spirifer mucronatus*, Conrad, from the Hamilton beds near Thedford, Ontario, and near Alpena and at other localities in Michigan. In the case of each of the mutations studied—mut. *alpenense*, Grabau ms.; mut. *multiplicatus*, Grabau ms.; mut. *profundus*, Grabau ms.; mut. *thedfordense*, Shimer and Grabau; and mut. *attenuatus*, Grabau ms.—distribution curves were plotted for adult and neanic shell indices, *i.e.*, $\frac{\text{Breadth}}{\text{Length}}$ ratios. From the results it was concluded that *alpenense* is ancestral to *profundus* and *thedfordense*, whilst

attenuatus and *multiplicatus* are derived from some common form similar to but somewhat more primitive than *multiplicatus*.

While the conclusions drawn by Mook are perhaps valid, the more purely statistical portion of the work calls for certain criticisms. Only 74 specimens of the form *attenuatus* were measured; the curves for *multiplicatus* are based on the still smaller number of 29 specimens. Yet in each case the percentage of shells within any given range of index is returned to the nearest one-tenth of one per cent., *i.e.*, in the case of *multiplicatus* the tacit assumption is made that the relations found for 29 specimens would hold exactly for one thousand. A much more serious point is that we are not told how the neanic measurements were obtained. Mook appears to have regarded all his examples as adult, however small they may have been; hence we find the neanic measurements of various individuals exactly the same as the adult measurements of other individuals; the latter therefore would appear to be immature (*e.g.*, neanic specimen no. 53=adult no. 38, etc.). Again, the neanic width is always given as equal to the adult width; thus, it is assumed that after the neanic stage has been passed the shell grows longer but not wider, the length of the hinge-line remaining unaltered. While the growth-lines are certainly much more crowded towards the ends of the hinge-line than they are near the anterior margin of the shell, increase in length is always accompanied by increase in width, *i.e.*, although $\frac{dw}{dl}$ diminishes very considerably as the shell increases in size, yet it is always appreciable. For these reasons the neanic curves of Mook are of very little value.

The measurements of every specimen are published, and these the writer proposes to use in order to obtain "growth-curves," so far as the data will allow.

In a recent note (4) the writer showed that in the case of the recent freshwater bivalve *Unio pictorum*, Linné, the ontogenetic curve of growth for the ratio antero-posterior length/dorso-ventral length, as determined by measurements from the growth-lines of individual shells, was in complete agreement with the phylogenetic curve obtained by measuring a large series of shells in all stages of growth and determining the mean value of the major axis which corresponded with each given dorso-ventral length. It is proposed to investigate the growth of various Brachiopoda by the method employed for the *Unio* above mentioned.

The Present Research.

In the present paper the writer proposes to give the results of a study of the series of *Reticularia lineata* (Martin) measured by Day. The specimens preserved in the Manchester Museum number nine hundred and forty-five (Day measured one thousand). Day did not accurately define the position of the three axes, Length, Breadth, and Depth, measured by him, and therefore no attempt had been made to discover whether the results of the measurement of the same series of shells by different observers were in accordance. Indeed, the values of the two ratios $\frac{\text{Width}}{\text{Length}}$ and $\frac{\text{Depth}}{\text{Length}}$ have not been determined, since the present investigation was undertaken with the object of studying the growth rather than the variation of the species.

The history of the species was sketched by Day, who also dealt at length with variations in certain characters less susceptible of measurement—variation in size, and lateral twisting of the ventral beak, ornament, etc.—as well as with variations in form. It is therefore unnecessary to treat of these features here.

Measurement. The three axes Length, Width, and Depth, were measured by means of an optician's sliding gauge, the determination being in every case correct to the nearest millimetre. The position of the axes may be defined as follows:—

Length. From the brachial umbo to the anterior margin, along the plane of symmetry of the shell. By measuring from the brachial umbo, irregularities due to variation in the relative size of the umbones—which are much greater in the case of the pedicle (ventral) umbo—are considerably diminished.

Width. The greatest width, perpendicular to the length axis and to the plane of symmetry.

Depth. The greatest thickness of the shell, perpendicular to the axes of width and length.

All shells of the same length were now got together, the whole series being thus divided up into a number of smaller series, each comprising shells which had attained the same length. In each of these small series width and depth distribution curves were plotted, and these were utilised to construct skeleton solid figures, in which the horizontal axes represent (1) length and (2) width or depth, the vertical axis representing the number of specimens The data on which these figures are based are given in Tables I and II, while photographs of the skeleton figures are shown in *Figs.* 1 and 2; the method adopted will probably be evident from Tables I and II (in constructing the solid figures outlying specimens have been disregarded).

TABLE I.

Comparison of Width with Length.

Length	Width	No.	Mean Width
3	4	1	4
4	4	6	4·25
	5	2	
5	5	12	5·54
	6	11	
	7	1	
6	6	9	6·81
	7	20	
	8	3	
7	7	7	8·08
	8	22	
	9	8	
	10	1	
8	8	5	9·42
	9	22	
	10	20	
	11	3	
9	8	1	10·82
	9	2	
	10	16	
	11	22	
	12	6	
	13	4	
10	10	2	11·92
	11	18	
	12	30	
	13	11	
	14	3	
11	11	3	13·48
	12	7	
	13	20	
	14	20	
	15	9	
	16	–	
	17	1	
12	13	7	14·79
	14	17	
	15	29	
	16	11	
	17	3	
13	14	6	16·09
	15	16	
	16	27	
	17	19	
	18	3	
	19	2	
	20	1	
14	15	5	17·38
	16	14	
	17	23	
	18	13	
	19	13	
	20	4	
15	15	1	18·79
	16	5	
	17	11	
	18	15	
	19	12	
	20	14	
	21	9	
	22	3	
16	17	3	20·02
	18	6	
	19	18	
	20	15	
	21	11	
	22	8	
	23	3	
	24	1	
17	19	4	21·64
	20	10	
	21	22	
	22	17	
	23	13	
	24	6	
	25	1	
18	18	2	22·93
	19	2	
	20	4	
	21	8	
	22	4	
	23	11	
	24	14	
	25	4	
	26	5	
	27	1	
	28	1	
19	21	1	25·08
	22	1	
	23	3	
	24	6	
	25	15	
	26	6	
	27	5	
	28	2	
20	22	2	26·02
	23	7	
	24	4	
	25	5	
	26	8	
	27	3	
	28	6	
	29	6	
	30	1	
	31	1	
21	25	6	27·06
	26	10	
	27	7	
	28	5	
	29	3	
	30	1	
	31	1	
	32	–	
	33	1	
22	25	1	28·47
	26	3	
	27	2	
	28	6	
	29	5	
	30	1	
	31	1	
23	29	2	30·0
	30	1	
	31	–	
	32	1	
24	33	1	33

TABLE II.

Comparison of Depth with Length.

Length	Depth	No.	Mean Depth	Length	Depth	No.	Mean Depth	Length	Depth	No.	Mean Depth
3	2	1	2	12	7	2	8·48	18	12	3	13·80
					8	34			13	22	
4	2	1	2·88		9	28			14	19	
	3	7			10	3			15	9	
5	3	15	3·38	13	8	7	9·20		16	2	
	4	9			9	47			17	–	
6	4	27	4·16		10	18			18	1	
	5	5			11	2		19	13	3	14·62
7	4	7	4·87	14	8	1	10·29		14	16	
	5	29			9	9			15	15	
	6	2			10	32			16	4	
8	5	25	5·58		11	28			17	–	
	6	21			12	2			18	1	
	7	4		15	10	7	11·17	20	14	6	15·84
9	6	33	6·35		11	48			15	12	
	7	18			12	11			16	13	
10	6	10	6·92		13	4			17	9	
	7	49		16	10	5	11·77		18	2	
	8	5			11	16			19	–	
11	6	1	7·72		12	33			20	1	
	7	22			13	11		21	15	6	16·68
	8	31		17	10	1	12·81		16	7	
	9	5			11	2			17	13	
	10	1			12	27			18	8	
					13	26		22	16	3	17·37
					14	14			17	6	
					15	3			18	10	
								23	18	1	19·0
									19	2	
									20	1	
								24	19	1	19

The solid figures show that *Reticularia lineata* presents a very good example of a truly homogeneous species: the variation shown is perfectly continuous throughout, and there is not the slightest evidence of any tendency towards a differentiation into two or more groups. Such solid figures may be taken as typical of "good," simple, homogeneous species.

Ontogeny. We may now safely proceed with a mathematical investigation into the ontogeny of the shell.

From the data necessary for the construction of the length-width and length-depth distribution figures the mean value of the width and depth respectively corresponding to each length was calculated. These mean figures are included in Tables I and II. They represent the average width and depth of shells

which have attained any given length, and have been utilised for the construction of *Figs.* 3 and 4. In *Fig.* 3 the mean width, and in *Fig.* 4 the mean depth, is plotted against the length. The same figures show also the range in width and in depth which was found amongst shells of each length—and again, the actual values may be found by reference to Tables I and II.

It should be observed that this method is only applicable in the case of species which show no tendency towards division into two or more groups: any such tendency is at once brought out by the solid distribution figures, and when evidence of a differentiation of this kind is found the ontogeny of the species cannot be directly studied by the method outlined above.

The remarkable smoothness of each of the ontogeny curves provides a very striking justification for the method by which they have been obtained. The discrepancy between the actual mean width or depth values and the corresponding points on the mean curves upon which they appear to lie is throughout very small. The two curves may now be considered somewhat more closely.

At the outset it may be remarked that the curves confirm the statement of Day that the ratios $\frac{\text{Length}}{\text{Width}}$ and $\frac{\text{Length}}{\text{Depth}}$ decrease throughout the life of the individual. But they show very definitely that the relationship which exists between Width and Length is by no means similar to that which is found between Depth and Length—a feature that the purely qualitative method used by Day could not be expected to bring out.

Fig. 3 shows that the width and length are related throughout life by a linear function, which may be expressed:—

$$w = 1{\cdot}35\ (l - 1{\cdot}0),$$

where l=length in mm., w=width in mm.

Two points of interest arise in this connection. Obviously, the line corresponding with this function does not pass through the origin: the width is directly proportional to a quantity which is roughly one millimetre less than the length as measured, *i.e.*, from the brachial umbo to the fold. Consideration of the form of the shell affords a fairly simple explanation of this. The brachial umbo projects to a slight extent behind the hinge-line; the extremities of the width axis lie in the plane of the hinge-line and the anterior margin, not in that of the brachial umbo and the anterior margin. Thus it appears highly probable that the width is directly proportional to the length from the hinge-line to the anterior margin. This suggestion is supported by the fact that 1 mm. is quite a fair average value for the difference between the lengths as measured from the hinge-line and from the brachial umbo respectively. No such correction for the length is necessary in the case of the relationship between depth and length.

The average values of the ratio $\frac{\text{Length}}{\text{Width}}$ are less than those

given by Day (*loc. cit.*, *Fig.* 4): it therefore appears likely that Day took his length from the pedicle umbo to the anterior margin —which would at once account for the fact that the rate of decrease of the ratio during the growth of the shell does not agree very closely with the rate which may (approximately) be deduced

$$\text{Since} \quad w = 1{\cdot}35(l - 1), \quad \text{we have:} \quad \frac{dw}{dl} = 1{\cdot}35 \; ;$$

i.e., the width increases at a constant rate, which is equal to 1·35 times the rate of increase of the length.

$$\text{Also} \quad \frac{w}{l} = 1{\cdot}35\left(1 - \frac{1}{l}\right) = 1{\cdot}35 - \frac{1{\cdot}35}{l}$$

$$\therefore \quad \frac{d\left(\frac{w}{l}\right)}{dl} = \frac{1{\cdot}35}{l^2} \; ;$$

i.e., as the length increases, the ratio $\frac{\text{Width}}{\text{Length}}$ increases rapidly at first and then more and more slowly, the increase being very small when the length is great.

The relationship between depth and length is rather less simple (*Fig.* 4). Over the whole range covered by the specimens studied, the two dimensions are very well expressed by the relation: $D = 0{\cdot}6643l + 0{\cdot}0011l^2 + 0{\cdot}000247l^3$; where D=depth, l=length, in millimetres. The agreement between the experimental values and the curve given by this equation is remarkably good (little weight is to be attached to the last two or three points found, on account of the relatively small number of such large specimens in the series).

$$\text{Since} \quad D = 0{\cdot}6643l + 0{\cdot}0011l^2 + 0{\cdot}000247l^3,$$

$$\therefore \quad \frac{dD}{dl} = 0{\cdot}6643 + 0{\cdot}0022l + 0{\cdot}000741l^2 ;$$

i.e., the rate of increase of depth increases more and more rapidly as the length increases.

$$\text{Further,} \quad \frac{D}{l} = 0{\cdot}6643 + 0{\cdot}0011l + 0{\cdot}000247l^2 ;$$

$$\therefore \quad \frac{d\left(\frac{D}{l}\right)}{dl} = 0{\cdot}0011 + 0{\cdot}000494l ;$$

i.e., the rate of increase of the ratio $\frac{\text{Depth}}{\text{Length}}$ increases at a constant rate as the length increases.

It is therefore evident that the relation between depth and length throughout growth is very different from that between width and length.

Summary and Conclusion.

It has been shown that:—

1. Length-Width and Length-Depth solid distribution figures strongly confirm the view that *Reticularia lineata* (Martin) from brachiopod-beds near Castleton, Derbyshire, is a perfectly homogeneous species.

2. Throughout life the length (l) from the brachial umbo to the anterior margin and the width (w) are connected by the relation:— $w=c_1(l-c_2)$, where c_1 and c_2 are constants.

It is suggested that c_2 is equal to the mean difference between the length from the brachial umbo and that from the hinge-line, to the anterior margin.

3 Simultaneously the depth (D) and length are related by the expression:—

$D=al+bl^2+cl^3$, where a, b, c are constants.

Finally, the writer would like to express his cordial thanks to Dr. G. Hickling, F.G.S., and to Mr. J. Wilfrid Jackson, F.G.S., for the kind interest they have taken throughout in the work; to Mr. J. Harwood, B.Sc., to whom the author is indebted for the photographs of the solid figures, and for considerable assistance in checking many of the calculations incidental to the analysis of the results; and to Professor Sydney Chapman, M.A., D.Sc., F.R.S., for the interest he has shown in the mathematical side of the work.

LITERATURE.

1. E. R. Cumings and A. V. Mauck.—"A Quantitative Study of Variation in the Fossil Brachiopod *Platystrophia lynx*." *American Journal of Science*, Ser. 4, Vol. 14, New Haven, 1902; p. 9.

2. Henry Day.—"Variation in a Carboniferous Brachiopod—*Reticularia lineata* (Martin). *Manchester Memoirs*, Vol. 59, Pt. 1, 1915; No. 4.

3. C. C. Mook.—"Statistical Study of Variation in *Spirifer mucronatus*." *Annals, New York Academy of Sciences*, Vol. 26, June, 1915; p. 175.

4. W. E. Alkins.—"Notes on the Growth and Variation of *Unio pictorum*, Linné. Read before the Conchological Society, May 14th, 1919 (not yet published).

Metallurgical Dept.,
The University, Manchester,
October 30th, 1919.

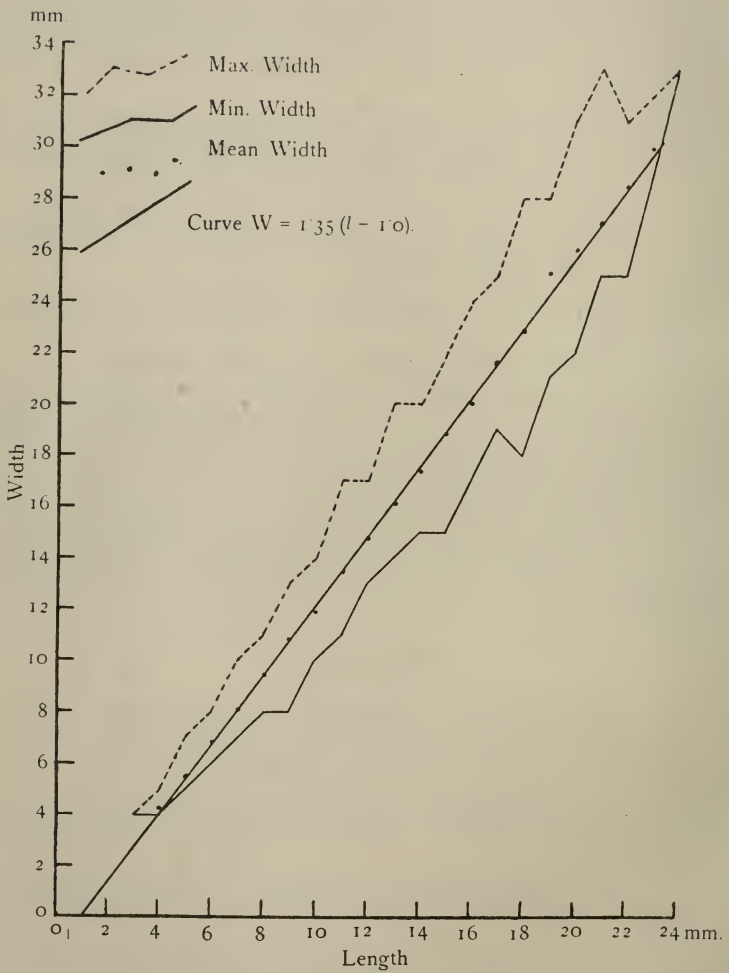


Fig. 3. **Relationship between Length and Width.**

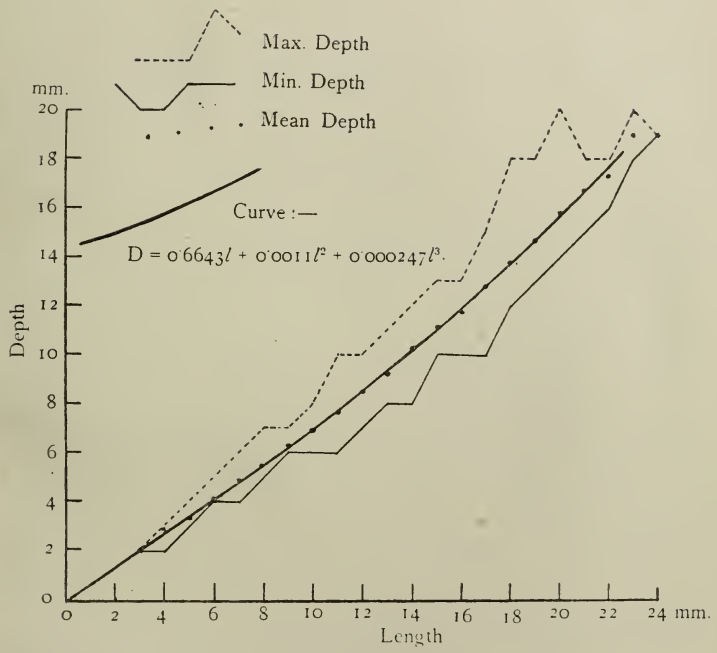


Fig. 4. **Relationship between Length and Depth.**

PROCEEDINGS
OF
THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 7th, 1919.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., F.C.S. (*Vice-President*),
followed by
Mr. WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C. (*Vice-President*),
in the Chair.

A vote of thanks was accorded the donors of the books on the table. Mr. C. L. BARNES, M.A., drew attention to several works, including:—"*A Bibliography of Indian Geology and Physical Geography . . .*" (Parts I. and II.) by T. H. D. La Touche (8vo., Calcutta, 1917, 1918), presented by the Director of the Geological Survey of India; and "*Spencer Fullerton Baird—a Biography*," by W. H. Dall (8vo., Philadelphia, 1915), presented by the Smithsonian Institution.

Gifts of a barometer, belonging to the late Dr. Henry Wilde, presented by Oxford University; a photograph of Dr. Henry Wilde, presented by Professor H. B. Dixon; thirty-two volumes of "*Memoirs and Proceedings*," presented by Mr. John Boyd; and volumes 2-9 of the Society's "*Proceedings*," from Mr. H. Crossley; were also recorded and votes of thanks passed to the donors.

An address on "**The Future of the Manchester Literary and Philosophical Society**" was given by Sir HENRY A. MIERS, M.A., D.Sc., F.R.S.

Sir Henry Miers referred to the discussion which took place on January 21st, 1919, at which it was proposed to make the Society more of a meeting place for persons generally interested in Science, and to give an opportunity for informal discussions. This was a work performed by such societies in their pioneer days; but with the increase of scientific knowledge the tendency has been for scientific people to segregate into special groups. As a result of this, the papers read at modern specialist societies are only calculated to appeal to experts.

A reaction is indicated by recent attempts at co-operation between the Humanities and Sciences, *e.g.*, in conferences, and the proposal for a common journal.

While nothing should be done to lower the tradition of the Society as a learned body promoting original research, it can do a great work by making the most recent advances in Science understood by those who are not experts, and by promoting joint meetings of various societies, at which new ideas can be expressed in language intelligible to all. Special lectures for working class audiences might also be instituted.

As the chief learned society in the district it is the natural convener of such conferences, through which it can counteract the present tendency towards specialisation of societies. There is danger of a scientific hierarchy, and of a cleavage between specialists and amateurs.

If investigators were encouraged in this Society to give popular expositions of their own discoveries to a general audience, in addition to the more severely scientific paper intended for publication, something would be done which has not yet been accomplished elsewhere.

The Society might also direct the attention of scientific workers of all sorts to problems which await solution, especially those which concern the Manchester district; and for this purpose bring other societies into touch with each other and with the University and College of Technology, and with the industries; acting as a sort of clearing-house by organising public lectures, special investigations, and other activities. In this way it might greatly assist the municipality by directing powerful intellectual forces to useful purposes.

General Meeting, October 21st, 1919.

Mr. WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C. (*Vice-President*), in the Chair.

Mr. FRANK LESLIE BARRETT, A.I.C., Research Chemist, Messrs. Tootal Broadhurst Lee Co. Ltd., and 15, *Russell Road, Whalley Range, Manchester;* Mr. JOHN HARRISON JAMESON, Engineer, 9, *Wilton Road, Chorlton-cum-Hardy, Manchester;* Miss MARY CUNNINGHAM, M.Sc. (Lond.), D.Sc. (St. Andrews), Research Chemist to the Fine Spinners' and Doublers' Association, Manchester, 6. *St. James's Square, Manchester;* Mr. HENRY STAFFORD GOLLAND, *Dunstan, Westminster Road, Eccles, Manchester;* Miss ALISON MCK. CRABTREE, Research Botanist, The Victoria University of Manchester, and 7, *Hague Road, West Didsbury, Manchester;* Miss M. I. MCCLATCHIE, M.Sc., Research Botanist, *The Manchester High School for Girls, Dover Street, Oxford Road, Manchester;* Miss ELAINE DE STE C. FOGG, B.Sc., Assistant Lecturer and Demonstrator in Botany in the Victoria University of Manchester, *The University, Manchester;* Mr. FREDERICK CHARLES WOOD, B.Sc. (Lond.), F.C.S., A.I.C., F.R.Met.S., Chemist, *c/o Messrs. Tootal Broadhurst Lee Co. Ltd.*, 56, *Oxford Street, Manchester;* and Professor T. H. PEAR, M.A. (Manc.), B.Sc. (Lond.), Professor of Psychology in the Victoria University of Manchester, *The University, Manchester;* were elected Ordinary Members of the Society.

On the Incorporation of the Manchester Chemical Club the following gentlemen were elected Ordinary Members of the Society :—

Mr. W. E. ALEXANDER.
Mr. MARCUS ALLEN, M.I.Mech.E.
Mr. E. A. ALLIOTT, B.Sc., A.M.I.Mech.E.
Mr. W. ANDREWS.
Mr. THOMAS ASPINALL, F.C.S.
Mr. S. S. AUSTIN.

Mr. JAMES BADDILEY.
Mr. H. J. BAILEY.
Mr. DAVID BAIN.
Mr. J. E. BALMER.
Mr. PERCY BEAN, F.C.S.
Mr. ERNEST BEARD.
Mr. A. W. BENNIS, M.I.Mech.E., A.I.E.E.
Dr. W. H. BENTLEY, F.C.S.
Mr. A. E. H. BLACKBURN.
Mr. JOSEPH BREWERTON.
Mr. J. H. BRIERLEY.
Mr. RAINALD BRIGHTMAN, M.Sc., F.C.S., F.I.C.
Mr. JAMES BRYANT.
Mr. G. A. BUCKLEY.

Dr. THOMAS CALLAN, M.Sc., F.C.S.
Mr. A. F. CAMPBELL, M.Sc., F.C.S., F.I.C.
Mr. DAVID CARDWELL, M.Sc., F.I.C.
Mr. C. W. CARPENTER, M.Sc.Tech., F.C.S., A.I.C.
Mr. JOSEPH CAUTHERY.
Mr. HOWARD CHEETHAM.
Mr. F. S. CHOATE.
Mr. W. H. COLEMAN.
Mr. J. A. COOMBS.
Mr. W. J. COOPER, F.C.S., F.I.C.
Mr. C. W. CRAWSHAW.
Mr. H. CRUSE.
Mr. P. CRYER.
Mr. J. B. CULLEN.

Mr. G. K. DAVIS.
Mr. H. E. DOUGHTY.
Mr. JOHN DOWNHAM, J.P.
Mr. WILLIAM DUCKWORTH.

Mr. H. J. EDGE.
Mr. JAMES EDGE.

Mr. WILLIAM FINLAY.
Dr. R. B. FORSTER.
Professor G. J. FOWLER, D.Sc., F.C.S., F.I.C.

Lt.-Col. EDWARD GARSIDE, B.Sc., M.Inst.C.E.
Mr. E. G. GAUL, M.Sc., F.C.S., F.I.C.
Mr. PERCY GAUNT.
Mr. S. W. GILLETT.
Mr. JAMES GRANT, M.Sc.Tech., F.C.S., F.I.C.
Mr. F. N. GRANT.

Mr. G. D. A. HALL.
Mr. B. H. HALSTEAD.
Mr. J. R. HANNAY.
Mr. J. H. HARGREAVES.
Mr. W. B. HART, F.C.S., F.I.C.
Dr. J. A. R. HENDERSON, F.C.S.
Mr. D. M. HENSHAW.
Mr. A. D. HEYWOOD.
Sir HENRY F. HIBBERT, Bart., J.P., F.R.G.S., F.S.S.
Mr. ANDREW HODGE.
Mr. T. R. HODGSON, M.A., F.C.S., F.I.C.
Mr. G. E. HOLDEN.
Mr. P. F. HOLMES, M.I.Mech.E.
Mr. T. A. HOLROYD, M.Sc., F.C.S., F.I.C.
Mr. A. L. HOLTON.
Mr. J. H. HOSEASON, F.C.S.
Mr. W. G. HUGHES.
Mr. HENRY HUMPHREYS.
Mr. HARRY HURST.
Mr. J. E. HURST.
Mr. T. W. S. HUTCHINS.

Mr. WILLIAM INGHAM, M.I.Mech.E.
Mr. J. M. IRVING.

Mr. FREDERICK JACKSON.
Mr. R. H. JACKSON.
Mr. I. R. JONES.

Mr. W. E. KAY, F.C.S.
Mr. J. E. KEIRBY.

Mr. J. E. LEA, B.Sc., M.I.Mech.E.
Mr. J. H. LESTER, M.Sc., F.I.C.
Dr. HERBERT LEVINSTEIN, M.Sc., F.C.S., F.I.C.
Mr. K. H. LIVERSEDGE.
Mr. C. J. LOMAX, M.Inst.C.E., M.Cons.E.
Mr. ERNEST LONG, A.M.Inst.E.E.
Mr. CYRIL LORD.
Mr. J. E. C. LORD.

Mr. WILLIAM MCCLEARY, F.C.S.
Mr. N. G. MCCULLOCH.
Mr. JAMES MCEWEN.
Mr. W. H. MACHIN.
Mr. JOHN MACKAY.
Mr. T. G. MARSH.
Mr. WILLIAM MARSHALL.
Lt.-Col. E. B. MARTIN, M.Inst.C.E.
Mr. H. E. MASON.
Mr. J. W. MELDRUM.
Dr. A. K. MILLER, F.C.S., F.I.C.
Mr. HAROLD MOORE, M.Sc.Tech., F.C.S., A.I.C.
Mr. H. N. MORRIS.
Mr. L. A. MOSS.

Mr. W. J. S. NAUNTON, M.A., M.Sc., F.C.S., F.I.C.
Mr. E. W. NORRIS.

Mr. OSWALD O'GORMAN.
Dr. W. R. ORMANDY.
Mr. JOHN ORMEROD.
Mr. W. H. ORMEROD.

Mr. J. DRUMMOND PATON, M.I.Min.E., A.M.I.E.E.
Mr. D. M. PAUL, B.Sc., A.I.C.
Mr. J. PAYMAN.
Mr. R. H. PICKLES.
Mr. HERBERT PORTER.
Mr. F. M. PROCKTER.

Mr. L. GUY RADCLIFFE, M.Sc.Tech., F.I.C.
Mr. JOHN REID.
Mr. G. F. ROBERTSHAW, F.C.S.
Dr. E. H. RODD, A.C.G.I., F.C.S., F.I.C.
Mr. W. D. ROGERS, B.Sc., A.R.C.S., F.C.S., F.I.C.
Mr. A. E. ROYSE.

Mr. HAROLD SANKEY.
Mr. F. SCHOLEFIELD.
Mr. A. R. SCOTT.
Mr. W. E. SHELLEY.
Mr. R. DES F. SHEPHERD, B.Sc.
Mr. STANLEY SMITH.
Mr. JOHN SNOWDON.
Mr. CHARLES SPACKMAN, F.C.S., F.I.C.
Mr. C. R. SPACKMAN.
Mr. R. A. STURGEON.
Mr. J. W. SUTCLIFFE.
Mr. W. S. SUTTON.
Mr. G. SYMONDS.

Mr. W. SCOTT TAGGART, M.I.Mech.E.
Mr. F. H. TERLESKI.

Mr. J. M. WALLWIN.
Mr. W. A. WALMSLEY, B.Sc., F.C.S.
Mr. THOMAS WARBURTON.
Mr. J. F. WARING.
Mr. GEORGE WATSON.
Mr. J. A. WEIL.
Mr. J. W. WELCH.
Mr. E. E. WIELER.
Mr. E. J. WILKINSON, F.C.S.
Mr. A. F. WILLIAMS.
Mr. H. E. WILLIAMS, F.C.S.
Mr. T. R. WOLLASTON, M.I.Mech.E.
Mr. W. W. WOODWARD.
Dr. W. WYLER.

Ordinary Meeting, October 21st, 1919.

Mr. WILLIAM THOMSON, F.R.S.E., F.S.C., F.I.C. (*Vice-President*), in the Chair.

A vote of thanks was accorded the donors of the books on the table. These included: "*Rats and Mice as Enemies of Mankind*" (Brit. Mus. Econ. Ser., No. 8), by M. A. C. Hinton (8vo., London, 1918), presented by the Trustees of the British Museum (Nat. Hist.).

Professor W. L. BRAGG, M.A., read a paper entitled "**Sound Ranging.**"

A sound spreads from the point where it originates as a spherical wave moving with constant velocity. If it is intercepted by three or more stations whose positions are accurately known, and if the time intervals elapsing between its arrival at the stations are measured, a simple construction gives the position of the source of the sound.

Soon after the commencement of hostilities it became clear that the struggle was going to take the form of trench-warfare. This gave rise to the idea of locating the enemy guns by sound in the way described above. The French made experiments with "Sound Ranging" in October, 1914, and showed that it was feasible, and the British Army was encouraged by their success to send an experimental Sound Ranging Section to the front. This section started operations in October, 1915, taking up its position opposite Wytschaete. At first the results obtained were poor, but they improved with experience and better apparatus. The original section became a training school for officers and men, and sufficient sections were formed to cover the whole of our front.

Each section had six microphones, spaced along a base opposite the German front line. The microphones were connected to a chronographic instrument at a central headquarters, and when the sound reached the microphone it sent an electric signal recorded by the instrument. In front of the base there were two observation posts so placed that the sound reached them a few seconds before it reached the microphones. This gave time for an observer at the post to press a key which started the recording apparatus at headquarters. By studying the record the time intervals could be measured and the position of the gun plotted on the map. This was then telephoned to the artillery.

There were between thirty and forty sections along the front. They could locate batteries between 10,000 and 15,000 yards away with a mean error of about 50 yards. An idea of the number of locations obtained may be gathered from the fact that each section sent in about one thousand results in the year.

The greatest difficulty was caused by adverse winds. If the wind were blowing from our side of the line towards the German batteries the sound never reached the microphones, being deflected into the upper air. This meant that in westerly weather Sound Ranging was of little assistance.

The results obtained by Sound Ranging and other means of location were used in the preparation of maps showing the positions of the enemy batteries. We did not always try to destroy an enemy battery which had been located, it was often advisable to find out as much as possible about it and leave it alone until occasion demanded that its fire should be neutralised.

Sound Ranging was a valuable means of getting information about the hostile batteries, and a very large proportion of the total number of locations were made in this way.

Towards the end of the war the sections were faced with the problem of moving their bases quickly to accommodate them to a front line which never remained in the same place for many days consecutively. They became expert in doing this and were able to give material assistance in the last stages of the struggle.

General Meeting, November 4th, 1919.
Professor F. E. WEISS, D.Sc., F.R.S., F.L.S., in the Chair.

At this General Meeting, summoned in accordance with the Articles of Association, an application having been received and approved by the Council for the formation of a CHEMICAL SECTION of the Society, the following resolution of the Council was submitted to the Society:—

> "That the Chairman and Secretary of the Chemical Section of the Society be added to the Council as *ex-officio* Members thereof."

This resolution was adopted.

Professor SYDNEY CHAPMAN, M.A., D.Sc., F.R.S., Professor of Mathematics and Natural Philosophy in the Victoria University of Manchester, *The University, Manchester;* Mr. W. H. PEARSON, M.Sc., A.L.S., 18, *Palatine Road, Manchester;* Mr. PERCY MCMICHAEL, Science Master, Central High School for Boys, Whitworth Street, Manchester, *Central High School, Whitworth Street, Manchester;* Professor W. J. SEDGEFIELD, M.A., Litt.D., Professor of the English Language in the Victoria University of Manchester, *The University, Manchester;* Professor MAURICE A. CANNEY, M.A., Professor of Semitic Languages and Literatures in the Victoria University of Manchester, and *Ingleside, St. John's Road, Knutsford, Cheshire;* Mr. NORMAN TUNSTALL, M.Sc., Lecturer in Physics, The Victoria University of Manchester, *The University, Manchester;* Professor A. J. TURNER, M.A., B.Sc., Professor in Textile Technology in the College of Technology, Manchester, *The College of Technology, Manchester;* Miss ALICE TABERNER, B.Sc., Research Student in Botany, The Victoria University of Manchester, *The University, Manchester;* Professor W. L. BRAGG, M.A., Langworthy Professor of Physics in The Victoria University of Manchester, *The University, Manchester;* and Dr. J. N. PRING, M.B.E., Lecturer and Demonstrator in Electro-Chemistry in the Victoria University of Manchester, *The University, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, November 4th, 1919.
Professor F. E. WEISS, D.Sc., F.R.S., F.L.S., in the Chair.

Professor WILLIAM H. LANG, M.B., C.M., D.Sc., F.R.S., gave a Lantern Demonstration on: "**One of the Simplest Land Plants, *Hornea Lignieri*.**"

The Lantern Demonstration illustrated the further results obtained by Dr. R. Kidston and Professor W. H. Lang in the study of the silicified Old Red Sandstone plants at Rhynie,

Aberdeenshire, now in course of publication by the Royal Society of Edinburgh. Two species of *Rhynia* are now distinguished: *R. Gwynne-Vaughani* and *R. major*. The latter is larger in all its parts than *R. Gwynne-Vaughani* and differs in some details of the anatomy. These plants are rootless and leafless and consisted of a subterranean rhizome with rhizoids, dichotomously branched cylindrical aerial stems and large terminal sporangia.

Another equally simple plant, associated with these in the Family Rhyniaceae, has been discovered and investigated. This is named *Hornea Lignieri* and consisted of rhizomes, branched stems, and terminal sporangia, without roots or leaves. The rhizomes were lobed parenchymatous structures, suggesting comparison with the protocorm of certain species of *Lycopodium*. The stems branched dichotomously, and had a simple central cylinder, cortex, and epidermis. No stomata have yet been discovered in this plant, as they have in *Rhynia*, but its organisation suggests a similar land-habit. The sporangia are remarkable in the presence of a columella-like central region making the spore cavity dome-shaped.

These simple Vascular Cryptogams suggest comparisons with Bryophyta and Algae.

General Meeting, November 18th, 1919.

Mr. WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C. (*Vice-President*), followed by Professor F. E. WEISS, D.Sc., F.R.S., F.L.S. (*Deputy Chairman*), in the Chair.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, was elected *President* of the Society in succession to Professor G. ELLIOT SMITH, M.A., M.D., F.R.S.

Following an announcement by Mr. WILLIAM THOMSON that Professor F. E. WEISS had, at the request of the Council consented to act as *Deputy Chairman* on such occasions as the *President* could not attend the Society's Meetings, Professor F. E. WEISS took the Chair.

Mr. ALFRED JOHN PENNINGTON, Research Chemist, *Oakley, Fallowfield, Manchester;* Mr. JOSEPH WATSON LEWIS, B.Sc., Assistant Physicist, Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, and 13, *Cawdor Road, Fallowfield, Manchester;* Mr. ALFRED CHARLES DUNNINGHAM, D.Sc., F.C.S., F.I.C., Chief Chemist of the Electro-Bleach and By-Products Ltd., Middlewich, and *Ashville, Middlewich, Cheshire;* Mr. THOMAS LAWRENSON, Manager of the British Dye Stuffs Corporation, Ltd., Middlewich Branch, Middlewich, and *Plas Newydd, Croxton Road, Middlewich, Cheshire;* and Mr. JAMES BOOTH SHARP, Aniline Colour Manufacturer, *Rookswood, Old Hall Road, Broughton Park, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, November 18th, 1919.

Professor F. E. WEISS, D.Sc., F.R.S., F.L.S. (*Deputy Chairman*), in the Chair.

A vote of thanks was accorded the donors of the books on the table. These included: "*A Subject Index to the Poems of Edmund Spenser*," by C. H. Whitman (8vo., New Haven, 1918), presented by the Yale University Press, New Haven, Conn.

Professor T. H. PEAR, M.A., B.Sc., read a paper entitled "**The Elimination of Wasteful Effort in Industry.**"

The lecturer pointed out that, it being impossible to distinguish sharply between physical and mental effort, in the investigation of the problems of economising human energy physiology and psychology must work side by side. While in many industries improvement of the external conditions of work such as temperature, ventilation, humidity, illumination, was rapidly proceeding, less had been attempted in the direction of improving the methods of work themselves. Examples of such efforts illustrated the importance of certain fundamental principles. The first was the adjustment, both in total length and in distribution, of rest pauses. By introducing suitably chosen rest pauses and by modifying the working attitude of girls who were engaged in folding handkerchiefs, the output increased 300 per cent. while the folders worked only 45 minutes in each hour and were less fatigued than before. The second principle was the substitution of habitual movements for constant acts of decision. By rearranging the method of "assembling" a braid machine, so that the parts were not only put together in a more efficient order, but were more easily found by the workman, 66 units were assembled by a man in one day instead of 18. The third was the elimination of useless movement. By this means the separate actions required to lay a brick had been reduced from 18 to 5; the output increased from 120 per man per hour to 350.

Insistence was laid upon the importance of teaching the best methods of work first, before the worker had acquired less efficient methods which were difficult to unlearn, and upon the necessity of such training being carried out by persons who knew how to teach. By analysing the results of motion study in a British munition factory during the war and similar improvements elsewhere, it was shown that "speeding up," fatigue, and the exploitation of the worker are by no means necessary results of such modifications. The question of the monotony alleged to be caused by such "shorthand" methods of work was also discussed. The fundamental confusion between the terms "monotonous"

and "habitual" was emphasised, and means were described by which the more efficient methods may increase interest in life both directly through their own nature and indirectly through the increased leisure, husbanding of energy and higher wages which they make possible.

In the discussion which followed, Dr. William Cramp, M.I.E.E., pointed out the dehumanising tendencies of experiments designed to achieve maximum output, and questioned the desirability of extreme specialisation from the point of view of the development of the individual. He suggested also that it was better to encourage individuals by lectures such as those of Professor Pear to take a pride in finding their own most efficient methods than to attempt to force upon them methods similarly deduced by the management.

General Meeting, December 2nd, 1919.

Professor F. E. WEISS, D.Sc., F.R.S., F.L.S. (*Deputy Chairman*), in the Chair.

Professor GEORGE UNWIN, M.A. (Oxon.), Professor of Economic History in the Victoria University of Manchester, and 47, *Heaton Road, Withington, Manchester;* Mr. ALFRED ERNEST STEINTHAL, M.A., B.Sc., Treasurer of the Victoria University of Manchester, 19, *Ladybarn Road, Fallowfield, Manchester;* The Reverend F. G. CHEVASSÛT, M.A. (Cantab), F.R.A.S., Warden of St. Anselm's Hall, *St. Anselm's Hall, Victoria Park, Manchester;* The Reverend T. NICKLIN, M.A., Warden of Hulme Hall, *Hulme Hall, Victoria Park, Manchester;* and Mr. A. E. HEATH, M.A., Lecturer in Education in the Victoria University of Manchester, *The University, Manchester;* were elected Ordinary Members of the Socity.

Ordinary Meeting, December 2nd, 1919.

Professor F. E. WEISS, D.Sc., F.R.S., F.L.S. (*Deputy Chairman*), in the Chair.

Mr. C. L. BARNES, M.A., drew attention to the following book on the table :—"*Chemical Abstracts, Decennial Index Vols. 1-10 (1907-1916), Subject Index L-Z,*" published by The American Chemical Society (8vo., Easton, Pa., 1919), purchased.

Mr. C. E. STROMEYER, M.Inst.C.E., M.Inst.M.E., explained a method by which roots of numbers can be easily and rapidly found by division sums. Let A^n be the number whose nth root is to be found, let G be a convenient number near to the probable value of A, then the approximate root is

$$R = G \frac{(n+1)\,A^n + (n-1)\,G^n}{(n+1)\,G^n + (n-1)\,A^n}$$

As it is desirable to know the accuracy of the result as measured by the approximate error $E = (A - R)$

$$E = \frac{n(R-G)\ (A'' + G'') - (A'' - G'')\ (R + G)}{n(A'' + G'') - (A'' - G'')}$$

The two denominators are the same.

Example. $\sqrt{2}$: Let $G = 1$. $R = \frac{7}{5} = 1{\cdot}4$.

Now let $G = 1{\cdot}4$. $R = 1{\cdot}4\ \frac{7{\cdot}96}{7{\cdot}88} = 1{\cdot}414214$.

Professor SYDNEY CHAPMAN, M.A., D.Sc., F.R.S., read a paper by Mr. L. V. MEADOWCROFT, B.A., M.Sc., entitled: "**A discussion of the theorems of Lambert and Adams on motion in elliptic and hyperbolic orbits.**"

This paper is printed in full in the *Memoirs*.

Mr. W. E. ALKINS, M.Sc., read a paper entitled "**Morphogenesis of** *Reticularia lineata*."

This paper is printed in full in the *Memoirs*.

General Meeting, December 16th, 1919.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Dr. JOHN KERFOOT WOOD, F.C.S., F.I.C., Lecturer in Physical Chemistry in the College of Technology, Manchester, and 31, *Rowan Avenue, Brooklands, near Manchester;* Professor ARTHUR GEORGE GREEN, M.Sc., (Leeds), F.R.S., F.C.S., F.I.C., Research Chemist, *Holloway Clough, Arthog Road, Hale, Cheshire;* Mr. FRANK LASSEY, B.Sc., Manager of the Manchester Branch, British Fibrocement Works, 414, *Corn Exchange Buildings, Manchester*, and *Northern Lea, Northenden Road, Sale, Cheshire;* Mr. WILLIS OPENSHAW HOWARTH, M.Sc. (Manc.), Lecturer in Botany in the Victoria University of Manchester, and *Fairlands*, 39, *Edge Lane, Chorlton-cum-Hardy, Manchester;* and Professor O. T. JONES, M.A. (Cantab.), D.Sc. (Wales), Professor of Geology in the Victoria University of Manchester, *The University, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, December 16th, 1919.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Professor F. E. WEISS, D.Sc., F.R.S., F.L.S., exhibited and made a few remarks on a green jade charm made by natives of New Zealand.

Mr. W. J. PERRY, B.A., read a paper entitled: "**The Historical Process.**"

The study of the geographical distribution of peoples in various stages of culture, and of the migrations of peoples, suggests that the degree of civilisation possessed by any community that has advanced beyond the pure hunting stage is the result, direct or indirect, of cultural influences propagated from some original centre. It seems as though the fundamental arts and crafts of civilisation were invented in one place, and that the knowledge of them was carried to the outlying parts of the earth, thus producing the various degrees of culture possessed by different communities. The study of archæological remains supports this contention.

If this conclusion be accepted, it becomes possible to regard the study of human society from a point of view different from that commonly adopted. We can examine the effects of various social institutions on behaviour. The hunting tribes, the most primitive men of whom we have direct knowledge, display a uniform type of behaviour: they are peaceful, truthful, monogamous, honest, kind to children and animals, and thus presumably represent the normal type of human behaviour. The people above them in culture have adopted the institutions of civilised peoples to varying degrees, and their modes of behaviour appear to correspond to their historical experience. The wide range of culture which exists in the world makes it possible to examine in detail the effects upon human beings of various social institutions, and thus to pave the way for the foundation of a Science of Society, the ultimate aim of which will be to determine which institutions are fitted to develop men to the greatest possible extent.

Mr. C. E. STROMEYER, M.Inst.C.E., M.Inst.M.E., read a paper on "**The Study of Nationalities,**" in which he pointed out that although structural peculiarities are very useful for differentiating non-related species they are of little use for the purpose of classifying branches of one species, and it is necessary to study their characteristics. He produced a paper which showed very clearly that there are very marked differences amongst the characteristics of different nationalities, for instance the semitic and slavonic races have wonderful memory gifts, and the Scandinavians are pre-eminently inventive. The author then dealt with the difficulties associated with the suggested study, pointing out that our words for the several characteristics have no very precise meanings, and he then dealt with the reagents which might be employed for revealing the fundamental characteristics of various nationalities.

General Meeting, January 6th, 1920.

Professor F. E. WEISS, D.Sc., F.R.S., F.L.S. (*Deputy Chairman*), in the Chair.

Mr. NORMAN S. HUBBARD, B.Sc., Metallurgical Research Department of the Broughton Copper Co., and 228, *Plymouth Grove, Manchester;* Mr. JOHN ALLAN, F.C.S., Technical Chemist, Chief Chemist at Messrs. Joseph Crossfield & Sons, Ltd., and 18, *Moorfield Road, West Didsbury, Manchester;* Mr. JAMES CHARLTON, Chemist, 40, *Lea Road, Heaton Moor, Stockport;* Miss MARJORIE DRURY, Secretary, Research Department, Messrs. Tootal Broadhurst Lee Co. Ltd., *c/o Messrs. Tootal Broadhurst Lee Co. Ltd.*, 56, *Oxford Street, Manchester;* and Miss AGNES CECILIA ALEXANDER, Physicist, Research Department, Messrs. Tootal Broadhurst Lee Co. Ltd., *c/o Messrs. Tootal Broadhurst Lee Co. Ltd.*, 56, *Oxford Street, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, January 6th, 1920.

Professor F. E. WEISS, D.Sc., F.R.S., F.L.S. (*Deputy Chairman*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Mr. R. W. JAMES, M.A., read a paper on "**The Antarctic: Shackleton's Expedition of 1914-17.**"

The aim of the expedition was to cross the Antarctic Continent. For this purpose, the main party was to establish a base as far south as possible in the Weddell Sea. From this base a sledging party was to cross the Continent, joining a supporting party from a second base established in the Ross Sea. The project could not be carried out, owing to bad ice conditions in the Weddell Sea preventing a landing. The "Endurance" was beset by ice in latitude 70° 30′ S., and after a nine months' drift was crushed and abandoned in latitude 69° 5′ S. on October 27, 1915. The crew formed a camp on the ice, which continued to drift north, and, $5\frac{1}{2}$ months later, were able to take to the boats, ultimately reaching Elephant Island in the S. Shetland Group on April 15th, 1916. From Elephant Island, Sir Ernest Shackleton, with a party of five, made a remarkable boat-journey in a 22 ft. boat, reaching South Georgia, nearly 800 miles distant, in 16 days, and was able to obtain help, and relieve the Elephant Island party, all well, on August 30, 1916, after four attempts.

The peculiar conditions handicapped scientific work considerably, nevertheless some valuable results were obtained. Two hundred miles of new coast line were mapped; a chain of soundings was extended across the Weddell Sea; and much interesting work done on the natural history of sea-ice.

Slides illustrating the drift of the "Endurance," the formation and decay of the pack-ice, the crushing of the ship and the life on Elephant Island were shown.

III.—Latent polarities of atoms and mechanism of reaction, with special reference to carbonyl compounds.

By Professor Arthur Lapworth, D.Sc., F.R.S.

(Read March 16th, 1920. Received for publication March 29th, 1920.)

The conception introduced by J. J. Thomson that the conventional valency "bond" between two atoms corresponds with the field between two opposite electrical charges situated on the atoms has been utilised by Ramsay, Fry and many other chemists to aid in accounting for phenomena of the most diverse character, such as the laws of substitution in the benzene series and the decompositions of citric acid and of aceto-acetic acid (Fry, *Zeitsch. physikal. Chemie*, 1911, **76**, 385, 398, 591; *J. Amer. Chem. Soc.*, 1908, **30**, 34; 1912, **34**, 664; 1914, **36**, 284, etc.; 1915, **37**, 855, etc.; 1916, **38**, 1323, etc. Hancke and Koessler, *J. Amer. Chem. Soc.*, 1918, **40**, 1726. Compare also Vorländer, *Ber. d. Deutsch. Chem. Gesellsch.*, 1919, **52** [B], 263.)

The writer has for a number of years used for his own guidance, and to a certain extent in teaching, a system of representing the activities of carbon compounds which involves the labelling of the atoms in the molecule with + and − signs, and with results which do not at first sight differ greatly from the figurations developed by Fry and others. In one very important particular he is in agreement with Noyes, Fry and others of this school in holding that the terms "positive" and "negative" have in the past been widely misapplied to many atoms and groups; for example, it has been customary to term $-NH_2$ a "positive" group, and acetyl $CH_3{\cdot}CO-$ a "negative" group, while in point of fact when these groups are united, forming acetamide, $CH_3{\cdot}CO-NH_2$, and set in competition with one another for the components of the water molecule, it is the acetyl group which attracts the truly negative hydroxyl and the $-NH_2$ group which attracts the positive hydrogen,

$$\left.\begin{array}{l} \overset{+}{\mathrm{H}} - \overset{-}{\mathrm{OH}} \\ \qquad \text{and} \\ \mathrm{NH_2{-}CO.CH_3} \\ \overset{-}{\qquad}\quad\overset{+}{\cdot} \end{array}\right\} \rightarrow \left\{\begin{array}{l} \overset{+}{\mathrm{H}} \qquad\quad \overset{-}{\mathrm{OH}} \\ \mid \quad \text{and} \quad \mid \\ \mathrm{NH_2} \qquad \mathrm{CO.CH_3} \\ \overset{-}{\qquad}\quad\overset{+}{\qquad} \end{array}\right.$$

October 22nd, 1920.

and every acceptable test of this kind leads to the same inversion of the customary application of the terms "positive" and "negative" to these two groups. The writer would propose the term "basylous" for such a group as $-NH_2$ which tends to lower the acidity of a molecule of which it forms but a part, and the term "acylous" for a group such as $CH_3{\cdot}CO-$ which has the opposite effect. Thus $-NH_2$, $-NHAlk.$, etc., are basylous, but almost invariably exhibit positive polarity when attached to carbon; $-H$ is basylous and usually positive; $-CO-$, $-SO_3H$ and $-NO_2$ are strongly acylous but usually positive; while $-OH$, $-OAlk.$, etc., are acylous and negative. Halogens are acylous and normally negative, but are positive when contrasted with $-OH$ or $-NH_2$.

$$\left.\begin{array}{c} \overset{+}{Cl}-\overset{-}{OH} \\ \text{and} \\ Cl-H \end{array}\right\} \longleftrightarrow \left\{\begin{array}{c} Cl \quad OH \\ | \text{ and } | \\ Cl \quad H \end{array}\right.$$

$$\left.\begin{array}{c} \overset{+}{Cl}-\overset{-}{NH_2} \\ \text{and} \\ HO-H \end{array}\right\} \longleftrightarrow \left\{\begin{array}{c} Cl \quad NH_2 \\ | \text{ and } | \\ HO \quad H \end{array}\right.$$

Compounds containing positive acylous groups yield acids by union with negative hydroxyl, and those with negative basylous groups yield bases with positive hydrogen (or $\overset{+}{H}+H_2O$). In the following pages the terms positive and negative are restricted to the application above indicated.

The writer originally fell into the habit of labelling the atoms in reactive molecules with + and − signs as the result of his applications of the ionic theory to the reactions of carbon compounds, and especially to those of ketones and allied carbonyl compounds. Thus it was evident that the addition of electrolytes to the carbonyl group invariably proceeded as if the carbon atom were more positive than the oxygen atom, and invariably selected the negative ion; for example,

$$\left.\begin{array}{c} >\overset{+}{C}=\overset{-}{O} \\ \text{and} \\ CN-H \end{array}\right\} \rightarrow \begin{array}{c} >C-O \\ | \quad | \\ CN \quad H \end{array}$$

conveniently indicated the course of the well-known cyanohydrin formation. It must be emphasised, however, that in attaching the − and + signs to the oxygen and carbon atoms no hypothesis is invoked, nor is it necessary or even desirable to assume that electrical charges are developed on these two atoms (except perhaps at the actual instant of chemical change). The signs are applied, in the first instance, merely as expressing the relative polar characters which the two atoms seem to display at the instant of the chemical change in question. In this respect the writer's views differ from those of Fry and others, and agree with those of Robinson.

The aldol reaction, in which compounds containing the groups $>CH-CO-$, $>CH-NO_2$, $>CH-CN$, etc., can replace the hydrogen cyanide in the addition process pictured in the paragraph immediately preceding, at once suggests that the hydrogen atom in these groupings has an enhanced positive polar character relatively to the carbon atom on which it is situated, and accordingly the writer expresses this by attaching a + and a − sign to these two atoms respectively. Combining this with the expression already developed for the carbonyl group, there is obtained the scheme:

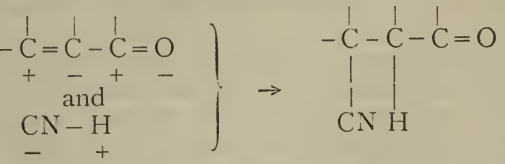
$$\begin{array}{ccccc} & & + & & \\ & & H & | & \\ & & | & | & \\ > & C & - & C & = O \\ & - & & + & - \end{array}$$

It may now be noted that this fusion suggests a property of the whole system which was not taken into consideration in deducing the signs for the two parts, and which, if absent, would render it impossible to justify the use of the scheme as a whole; this property concerns the two carbon atoms, which are here necessarily shown as having opposite polarities with respect to one another, and in the same sense as with the hydrogen atom and the carbon atom on the left. Fortunately there is plenty of evidence in favour of the existence of latent polarisation in a pair of carbon atoms situated as in the above scheme; thus hydrolysis of such a complex usually if not invariably takes place as follows:—

$$>\overset{-}{C}H - \overset{+}{\underset{|}{C}} = \overset{-}{O} + \overset{+}{H} - \overset{-}{O}H \rightarrow >\overset{+}{C}HH + HO\cdot\overset{-}{\underset{|}{C}} = O.$$

Significant too are the properties of $\alpha\beta$-unsaturated ketones,

etc., where it is clear that the doubly linked carbon atoms and the carbonyl group are to be labelled as in the scheme



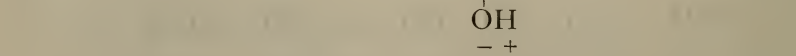
As a considerable step in advance of this may be quoted the fact, foreseen and established by the writer eighteen years ago, that the hydrogen atoms of the γ-position in ethyl crotonate have properties precisely corresponding with those of the hydrogen atoms in the α-position in saturated carbonyl compounds (*Trans. Chem. Soc.*, 1901, **79**, 1273), so that the formulation $H-CH_2\cdot CH:CH\cdot COOEt$ must be adopted to express this.

Combining this with the scheme developed immediately above there results the extended form:

$$H-CH_2-CH=CH-C(=O)OEt$$

and although, at present, it is difficult to find direct justification for the implied relative polarities of the two bracketed carbon atoms, the weight of evidence in favour of the conclusion that the carbonyl group tends to develop alternate − and + latent polarities in a chain of atoms is so considerable that it seems reasonable to proceed with the further development of the principle in the confident belief that this solitary hiatus will disappear in due course.

The polar properties of crotonic aldehyde are no doubt to be represented by a precisely similar scheme, and the more recent work of Raper and of Mrs. MacLean on the synthetic production, from aldol and crotonic aldehyde, of compounds containing straight chains of eight carbon atoms furnishes evidence of this, and suggests that the biochemical synthesis of fatty acids is regulated by the principle of alternating latent polarities.



It must now be evident from the cases already dealt with, that the whole order of alternating latent polarities is determined

by the oxygen atom or atoms, for the rest of the molecule consists of carbon and hydrogen atoms only. The influence of $-NO_2$, $-SO_2-$, and $-CN$ when in attachment to carbon differs, however, only in degree from that of carbonyl; hence it would appear that with the first two the effect of the group on the rest of the molecule is again determined by the oxygen atoms and in the last by the nitrogen atom. The analogy between the four different groups may therefore be indicated as follows, where in each case the "key-atom" is suggested by addition of a "dot" to the sign used for its latent polarity.

$$\begin{array}{l} C-C-C=O \\ +\ -\ +\ \dot{-} \end{array} \qquad \begin{array}{l} C-C-N\equiv O_2 \\ +\ -\ +\ \dot{-} \end{array}$$

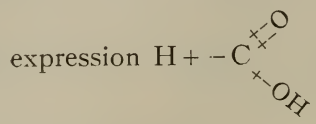
$$\begin{array}{l} C-C-S\equiv O_2 \\ +\ -\ +\ \dot{-} \end{array} \qquad \begin{array}{l} C-C-C\equiv N \\ +\ -\ +\ \dot{-} \end{array}$$

The writer has long held that certain atoms, and especially divalent oxygen and tervalent (negative) nitrogen, tend to produce such an alternation of latent polarities within the molecules in which they occur. These two atoms are as a rule much more effective than the halogens and, where they are in competition, the influence of the oxygen usually appears greater than that of the nitrogen. A perceptible influence of the opposite kind appears to be exercised by hydrogen. Carbon itself (in part no doubt because it is the standard of reference) appears nearly indifferent, as also does quinquevalent nitrogen.

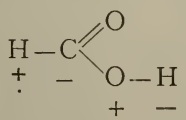
The extension of the influence of the directing, or "key-atom," over a long range seems to require for its fullest display the presence of double bonds, and usually in conjugated positions; consequently the principle must find ample scope in the aromatic series where conjugation is the rule. The ready substitution of the γ-hydrogen atoms in ethyl crotonate was shown by the writer in 1901 to provide an exact parallel with the behaviour of the hydrogen atoms in the methyl group of *o*- and *p*-nitrotoluene, and both were shown to be cases of "meta-substitution." The scheme

$$\begin{array}{l} \qquad\qquad\quad CH=CH \\ \qquad\qquad\quad\ \diagup\qquad\diagdown \\ H-CH_2-C=C-CH=C-N\equiv O_2 \\ +\ \ -\ \ \ \ +\ \ |\ -\ +\ \ \ -\ +\ \ \dot{-} \\ \qquad\qquad\quad\ H \\ \qquad\qquad\quad\ + \end{array}$$

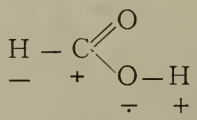
illustrates the far-reaching influence of the polarising "key-atoms" on the properties of the hydrogen atoms both in the *meta* position and in the methyl group of *p*-nitrotoluene and the relation between this arrangement and the less extended one for ethyl crotonate strengthens the case for concluding that the influence of any "key-atom" on a chain of other atoms is to influence their latent polarities in the sense which the writer attaches to the alternating + and − signs of the preceding schemes.

It is this kind of influence which the writer considers to have the greatest importance in the development of the principle of latent polarities and which should always be expressed in employing it. The expression  , adopted by Fry and other authors of this school, for formic acid (compare *J. Amer. Chem. Soc.*, 1914, **36**, 1035) is used by them to express several, probably unrelated, properties of the acid simultaneously. It is doubtless quite consistent with Thompson's theory of a bond; but this theory provides no explanation of the principle which the present writer desires to emphasise and with which principle such formulæ are inconsistent.

Formulæ A and B indicate the application of the principle of alternating latent polar influences as expressing the influence of the methin hydrogen atom and the hydroxylic oxygen respectively in modifying the latent polarities of the other atoms in the chain of four :—

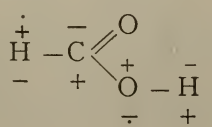


(A)



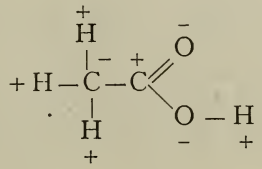
(B)

There are possibly two isodynamic phases of the molecule or, much less probably, the effects are superimposed, in which case an expression



would make clear the two opposing, doubtless very unequal, influences.

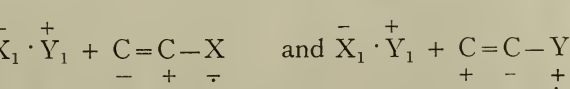
The arrangement of the molecule of formic acid may be said to be *heterogeneous* from the point of view just elaborated; acetic acid on the other hand is wholly *homogeneous*, the signification remaining the same no matter which of the oxygen or hydrogen atoms is imagined to act as " key-atom,"



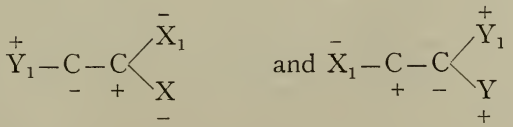
and the same is true of aceto-acetic acid (Hancke and Koessler, *loc. cit.*).

In order to emphasise that aspect of the question of polarities to which he attaches special importance the writer would suggest terming it the " principle of induced alternate polarities."

It is evident that the rule of Markownikoff is at once the most natural and elementary outcome of the principle in question, as the addition processes



must give rise to



or, in words, to the accumulation of atoms or groups of like polar character on the same carbon atom.

It would seem that, in general, the reversible reactions are those which lead to the most homogeneous arrangements, as in the aldol, acetoacetic ester and Raper-MacLean syntheses; heterogeneous arrangements appear usually to arise as the result of depolarisation effects analogous to oxidation or reduction: but this issue as well as that of variable valency and consideration of amphoteric groups like $-CN$ must for the present be deferred.

The influence of one atom in a molecule in modifying the polar character of another is well illustrated by the properties conferred on halogen atoms by oxygen atoms variously situated with regard to them. For example, with the grouping

$$\overset{+}{\mathrm{Cl}}-\overset{-}{\mathrm{C}}-\overset{+}{\mathrm{C}}=\overset{\mp}{\mathrm{O}}$$

there is abundant evidence that the chlorine atom has an enhanced tendency to act as a positive, and a diminished tendency to react as a negative, component; it is, for example, frequently difficult to replace it except by positive hydrogen. Thus, the α-chloroderivatives of camphor are not converted by alkalies or silver hydroxide into hydroxycamphor, and in the case of *αα′-di*chloro-camphor alcoholic sodium hydroxide actually causes replacement of one chlorine atom by hydrogen, the product being *mono*chlorocamphor. Again, the α-halogen derivatives of ketones, and especially of 1 : 3-diketones and 1 : 3-ketonic esters, react excessively readily with hydrogen iodide in dilute solution (Kurt Meyer's test for *enol* forms), and even with hydrogen bromide, free halogen being liberated

$$\overset{+}{\mathrm{H}}-\overset{-}{\mathrm{Br}}+\overset{+}{\mathrm{Br}}-\mathrm{C}-\overset{+}{\mathrm{C}}=\overset{\mp}{\mathrm{O}}$$

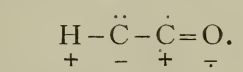
On the other hand the properties of halogen in the β-position in carbonyl compounds offers a striking contrast with this. The *αβ-di*halogen derivatives, when halogen hydride is withdrawn, lose the halogen atom from the β-position, which fact indicates that the latent polarity of the β-halogen in these compounds is negative. Combining this result with that above deduced for the α-halogen derivatives, it is seen that the scheme

$$-\overset{\overset{+}{\mathrm{Br}}}{\mathrm{C}}-\overset{\overset{-}{\mathrm{H}}}{\overset{+}{\mathrm{C}}}-\overset{+}{\mathrm{C}}=\overset{\mp}{\mathrm{O}}$$

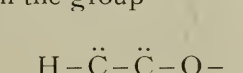
expresses all the data drawn attention to, and is one in which the oxygen atom functionates as "key-atom." It is perhaps doubtful whether the influence of the oxygen atom extends so

far as the β-halogen atom and whether the lability of the latter atom is not consequent on the induced polarity of the α-hydrogen atom; such a question awaits further experimental evidence. Space does not permit of discussion of possible phases of, or effects in, the above arrangement of atoms when the halogen atoms in their turn exercise functions as "key-atoms."

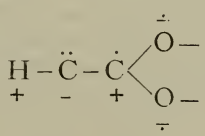
It may at this point be emphasised that while double (and treble ?) bonds are highly effective when suitably disposed for carrying on the influence of a "key-atom" over a long chain, similar influences may often be traced, though as a rule less clearly, in the entire absence of double bonds. Thus the decided lability and latent "positiveness" of the hydrogen atom noticed in the group



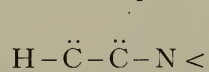
is also discernible in the group



for ethyl ether readily yields *αβ-di*chloro derivatives, and ethyl alcohol condenses with certain aldehydes in virtue of labile hydrogen in its methyl group. More evident is the combined effect of two singly bound oxygen atoms homogeneously arranged :—

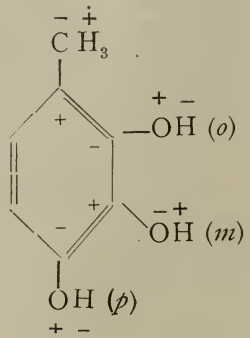


for the α-hydrogen atom of acetals is very easily substituted. It may with confidence be anticipated that the corresponding hydrogen atoms in amines will prove to be similarly reactive—



In illustration of the wide application of the principles which the writer conceives to be associated with atoms capable of inducing or affecting intramolecular polarisation, reference

may be made to the three isomeric cresols. In these the influence of the hydroxylic oxygen as "key-atom" on the hydrogen atoms of the methyl group will evidently be such, if anything, as to increase their "positiveness" in the homogeneous *m*-cresol and to depress it in the heterogeneous *p*- and *o*-cresols. The influence of the methylic hydrogens, acting as "key-atoms," on the hydroxylic group, is as indicated in the generalised scheme—



The enhanced degree of polarisation, $-\overset{-}{O}-\overset{+}{H}$, in the hydroxyl groups of the homogeneous *m*-cresol contrasted with the opposite effect in the other two isomers, indicates that *m*-cresol is the most acidic of the three; in *o*-cresol the proximity of the $-OH$ group to the "key-atoms" suggests that in this compound their depressant influence will be more marked than in *p*-cresol. This arrangement, *m*-, *p*-, and *o*-cresol, in descending order of acidity, is precisely what is found to hold good. (Dawson and Mountford, *Trans. Chem. Soc.*, 1918, **113**, 987.)

Comparison of the cresols with phenol is not admissible, as the general basylous effect of methyl as compared with hydrogen would have to be taken into consideration, just as, for example, would have to be done in comparing acetic acid with formic acid; in both cases methyl depresses the acidity.

Whilst the principle of induced alternate polarities serves to group together a large number of otherwise apparently disconnected data, it is likely to remain comparatively infertile unless considered in conjunction with more purely chemical features, and especially with the question of free, partial and latent valencies and their interactions of which conjugation may be specified as a type.

In past years the writer endeavoured to develop schemes for reactions of carbon compounds on the assumption that those reactions were usually ionic in character. A mass of evidence has accumulated during the intervening years which tends to show that even those changes which in the main proceed through the ions have a parallel non-ionic course also, and that frequently the two proceed simultaneously and with the same end results, polarity considerations evidently affecting both identically. In seeking schemes to represent the course of such changes the writer holds that it is most satisfactory to seek first an explanation of the reaction in its ionic phase and subsequently to deduce the scheme for the reaction between the non-ionised components, the advantage of this course being that in nearly all instances only one of the radicles (or ions) of the electrolyte is chemically active and the ionic reaction must involve this one only at the critical stage—for example, OH' in alkaline saponification and CN' in cyanohydrin formation. These ions are weak in comparison with, say, NO_3'; they have therefore less tendency to a stable diffuse distribution of their valencies, and tend to lose their ionic state by concentrating their diffuse valency on a single atom of another substance, especially if that atom itself has a decided polar character, inherent or induced. So, for instance, H·CN, $H{\cdot}SO_3H$, etc., do not unite with an ethylenic bond, unless this is polarised as in $\alpha\beta$-unsaturated ketones, and are thus distinguished from HO·Cl, $ON{\cdot}NO_2$ and Br_2, for example, which frequently attach themselves to non-polarised ethylenic bonds.

In order to indicate, necessarily very crudely owing to considerations of space, how the writer conceives these various aspects to contribute to the mechanism of chemical changes, he has selected three cases to which he attaches special interest. In the diagrams used he has followed Robinson in dividing a distributed valency into fractions, usually three, which total to the exact value of the single undistributed valency. A single valency is as usual indicated by an uninterrupted line and the fractions by dotted lines. The "latent polarities" of the atoms are indicated by the signs + or −, so that a molecule is electrically neutral when an equal number of free valencies proceed from positively and negatively polar atoms, while an ion has an excess of free valencies (which total to a whole number) proceeding from atoms of the one kind.

The first case is that of the formation of acetonecyanohydrin which must be conceived as due either to the formation of a complex ion, from cyanion and acetone, or by direct addition of a metallic cyanide to acetone (compare *Trans. Chem. Soc.*,

1903, **83**, 100; 1904, **85**, 1206. *Zeitsch. Electrochem.*, 1904, **10**, 582). The cyanidion, Cy, in *Fig.* 1 is represented with a diffused valency which passes into space, to the solvent or to surrounding kations. The reactive phase of the acetone molecule is indicated with equal quantities of + and − partial free valency and consequently as electrically neutral; the arrangement of free partial valencies by which it attracts agents is precisely as conceived by Thiele. The stages (*b*) and (*c*) are intermediate types of univalent negative ions with diffused valency and lead to (*d*) which is the normal ion of the potassium derivative (*e*). (The metal derivative has been shown to be the intermediate compound in the formation of cyanohydrin from benzaldehyde and from camphorquinone. Compare *Trans. Chem. Soc.*, 1904, **85**, 1208 and 1210.)

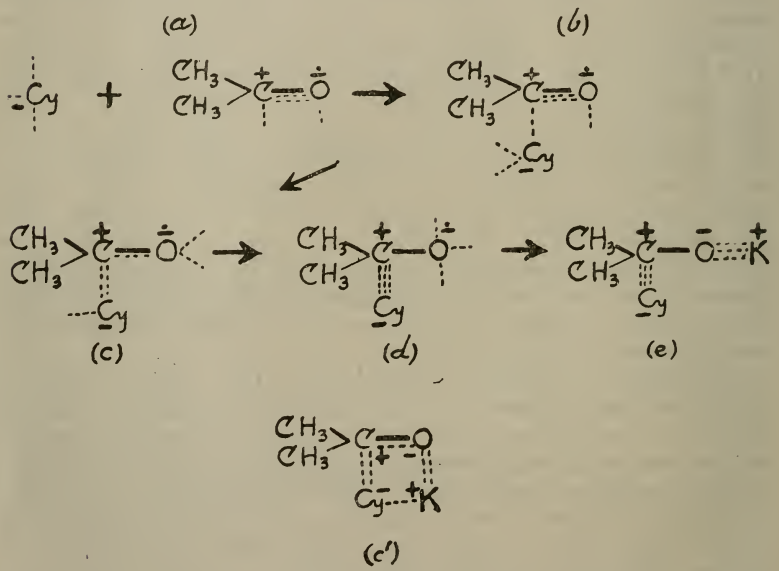
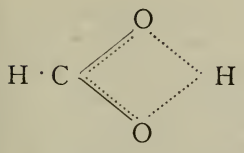
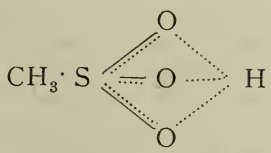


Fig. 1.

The expression (c′) in *Fig.* 1 represents the non-ionic phase corresponding with (c) and is consistent with the tendency of powerful ions such as K· to exercise their valency in diffuse form (compare Briggs, *Trans. Chem. Soc.*, 1908, **93**, 1564; 1917, **111**, 253; 1919, **115**, 278). In the same connexion it is worthy of note that most of the more powerful acids, and possibly all acids, are those in which the structure of the anion provides the possibility of such a diffuseness of valency.



Formic acid.



Methanesulphonic acid.

The formula for the carboxyl group, in the first of these, is identical with that proposed by Hantzsch, and is for the foregoing reasons eminently acceptable.

In *Fig.* 2 are indicated the stages which the writer conceives to represent the conversion of the ketonic group (i), into the ion (vi) of the *enolic* modification by the influence of hydroxyl ions. It can be shown that any view involving the assumption of addition of hydroxylion to the carbonyl group would not be helpful, as this occurrence would rather tend to weaken attachment of the bond between the two carbon atoms and to strengthen the attachment of the hydrogen atom; this course is doubtless what is followed during, for example, the alkaline hydrolysis of acetoacetic ester. The dissolving in alkali of the *ketonic* form of a substance (as the sodium salt of the *enol* form), is easy to understand when the principle of "induced alternate polarities" is considered in conjunction with a very natural extension of Thiele's theory of partial valencies.

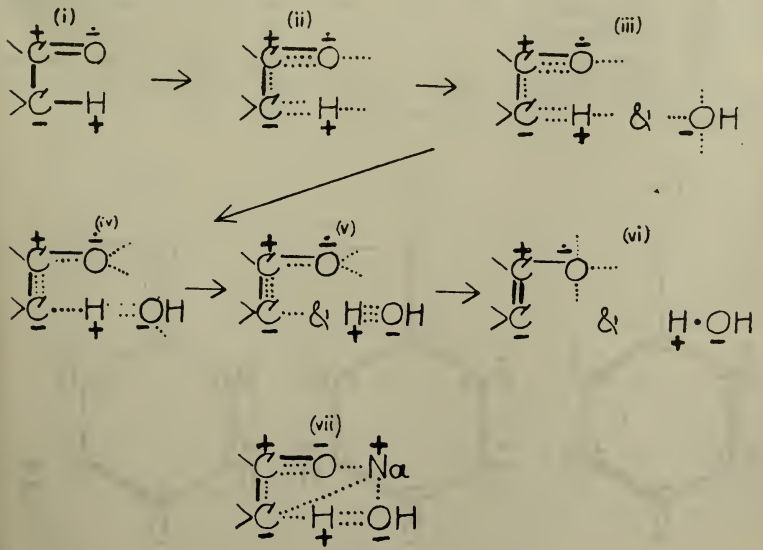
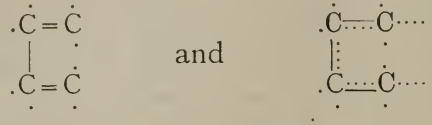


Fig. 2.

The ketonic form (i) is devoid of acid properties, or, in other words, the hydrogen atom is not directly ionisable. Under the influence of the " key " oxygen atom, however, it is endowed with some additional positive polarity. In the structure (ii) we have a rearrangement of the partial valencies analogous in all fundamental respects to Thiele's expression for conjugated systems, the relation between (i) and (ii) being the same as between



In (ii) the hydrogen atom attains only what may be termed incipient ionisation (in other words, a polar character with partially diffused valency), but in virtue of this is able to attract the negative hydroxyl ion. The subsequent changes leading to the formation of non-ionised water and the kation of the enol form in (vi) are now obvious.

No difficulty whatever is found in figuring the non-ionic analogue of any of these stages. Thus (vii) may be developed as the non-ionic form of (iv); and here again the diffuseness of the partial valencies of the metallic radicle and the acid radicle is consistent with what has been emphasised in the preceding paragraphs.

The formulæ given in *Fig.* 3 illustrate as fully as can be done within a limited space some of the applications of the principles in the aromatic series.

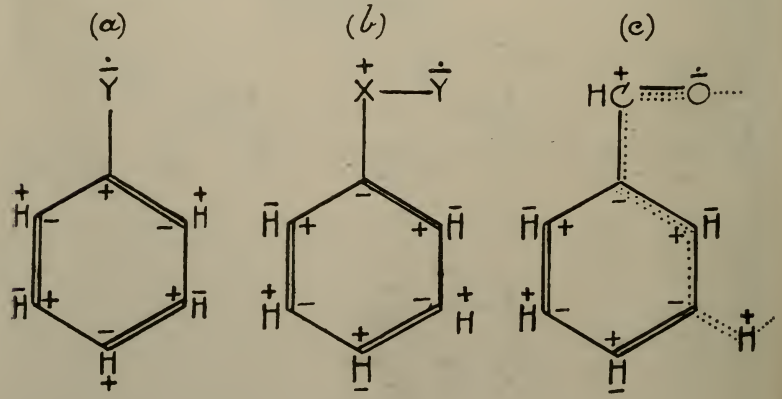
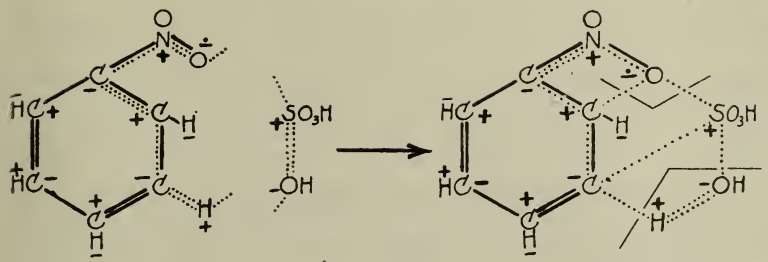


Fig. 3.



(i) (ii)

Fig. 3 *continued.*

The formula (*a*) is a type of *mono*-substituted benzene derivative which gives mainly *o*- and *p*-*di*-derivatives on further substitution, and Y may be *di*-valent $\dot{\dot{O}}$, *ter*-valent $\dot{\dot{N}}$, halogen, etc. On the other hand (*b*) is the type which mainly yields larger quantities of *m*-*di*-derivative, and here Y may be the *di*-valent O of $>\dot{\dot{C}}O$ or $>\dot{\dot{N}}O_2$, the *ter*-valent N of $-\dot{\dot{C}}N$, the halogen of quaternary ammonium salts, $-\dot{N}(CH_3)_3.Cl$, or of $-\dot{C}HCl_2$ or $-\dot{C}Cl_3$. In the case of toluene it is not improbable that the hydrogen of the methyl group is the " directive " or " key " atom, so that in addition to (*a*) and (*b*) it may be necessary to add a third type with $-\overset{-}{Y}-\overset{+}{X}$, as side group with *o*- and *p*-directive influence.

Schemes very similar to (*a*) and (*b*) have been used previously by Fry, Vörlander and others, but with less stress on the influence of the " key " atoms as the paramount one; moreover, when Fry attaches alternating + and − symbols to successive atoms he does so on an *ad hoc* basis and is at no pains to show that this alternation is so general as the present writer has attempted to demonstrate. The principle of alternating latent polarities does not appear to follow from Thomson's theory of a bond, and Fry's formulæ are often wholly at variance with the principle in question.

The writer raises the case of *meta*-substitution in some detail, as he drew attention to its connexion with the case of α-substitution in the fatty series many years ago. Formula (*c*) in *Fig.* 3 represents his conception of the reactive phase of the benzaldehyde molecule preparatory to attack by a substituting agent in the *m*-position; comparison of this formula with (ii), *Fig.* 2, will make the exact analogy clear.

The corresponding phase of nitrobenzene prior to attack

by sulphuric acid is shown in (i), *Fig.* 3; any process of normal substitution of $\overset{+}{H}$ in this phase by $\overset{+}{SO_3H}$ must give rise to the *meta*-sulphonic acid. Formula (ii), *Fig.* 3, represents a hypothetical stage in the intermediate compound which, by breaking down in the manner indicated, gives nitrobenzene*meta*sulphonic acid and water. Attention may be drawn to a figure which was developed by the writer in 1898 (*Trans. Chem. Soc.*, 1898, **73**, 456) in order to account for *meta*-substitution in nitrobenzene; the older figure is in all essentials wholly consistent with the one given above. In (ii), *Fig.* 3, the identity of the intermediate stages involved in direct sulphonation in the nucleus and in migration of the SO_3H from a hypothetical position on the O atom of the nitro-group to the *meta*-position, is most clearly suggested; with the introduction of the conception of partial valencies, however, the need of representing the *meta*-carbon atom as strictly doubly bound at any stage to each of two others as in the earlier explanation no longer exists.

In the preceding pages the writer has endeavoured to demonstrate the generality of the principle of alternate latent polarities as set by a "key atom." He has made no attempt to account for the principle, which at least is certainly not a consequence of Thomson's theory of the bond, but is possibly a mathematically necessary corollary of the mechanism of chemical change as regulated by the requirements of constant valency. For the present he is content (1) to have demonstrated that the generality of the principle is independent of hypothetical considerations, and (2) to have indicated a number of applications of the principle which may prove fruitful in suggesting new lines of investigation.

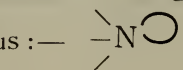
In taking the present opportunity of outlining his views on the questions of latent polarities and mechanism of reaction, the writer is conscious that these views have to a large extent been built up by the selection from many sources of ideas which appeared to be helpful in developing the generalisations to which he drew attention in 1898 (*loc. cit.*) and 1901 (*Trans. Chem. Soc.*, 1901, **79**, 1265 *et seq.*). Thiele's views have since virtually determined the lines of development of the valency aspects of organic chemical theory, but the writer has also been greatly influenced from time to time by the work of Hantzsch and Flürscheim, and of late by those especially of Briggs and of Robinson, to each of whom acknowledgments are due.

Manchester Memoirs, Vol. lxiv (1920), *No.* 4

IV.—The Conjugation of Partial Valencies.

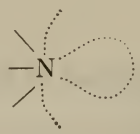
By Professor Robert Robinson, D.Sc., F.R.S.

(*Read March 16th, 1920. Received for publication August 9th, 1920.*)

During the past five years the author has made use of a hypothesis which has appeared to simplify the representation of the possible mechanism of reactions in certain isolated cases, and the object of the present communication is to indicate some of the lines along which the theory may receive more general application. The necessary condition precedent to chemical change is assumed to be the "activation" of one or more of the molecules taking part in the reaction; this is followed by cohesion and rearrangement of valencies, most probably synonymous with changes in position of electrons. The result is either molecular rearrangement, the formation of an additive product or of new substances by fission of the complex. The activated molecules are further assumed to be polarised and to contain partially dissociated valencies. Thus H – Cl is supposed to be chemically inert, the molecule absorbs energy and becomes . . . . H . . . Cl . . . which is the reactive form termed partially dissociated because it is a stage towards complete ionisation. In thus splitting a valency it is always understood that the two or more dotted lines, though not necessarily themselves of equal value, are quantitatively equivalent in the sum to the normal unit valency from which they have been derived and the polar character of all these fractional valencies is identical. It is possible to allocate definite signs to the partial valencies in most cases as the result of a consideration of the relative polarities of atoms evinced for example in the limiting case of true electrolytic dissociation. A significant exception to the rule that partial valencies of similar sign emanate from the same atom at the same time exists in the case of those elements which exhibit latent valancies such as trivalent nitrogen. A neutral nitrogen atom is represented thus :— 

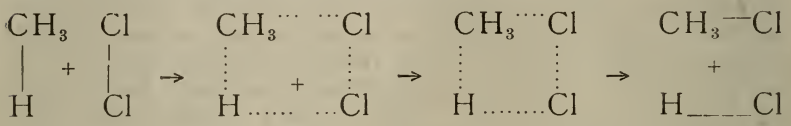
March 22nd, 1921.

and the loop, it is supposed, can be opened up in stages with the result that two partial valencies of opposite sign are produced. This condition of affairs may be expressed by the symbol :—

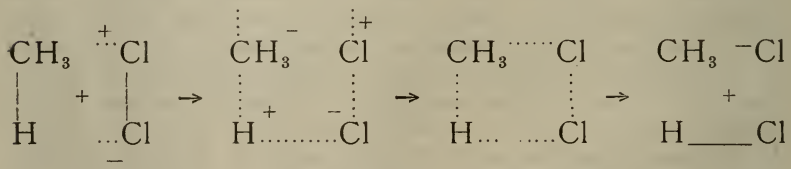


The chlorination of methane may be given as a simple illustration of the representation of a reaction in accordance with the above postulates :—

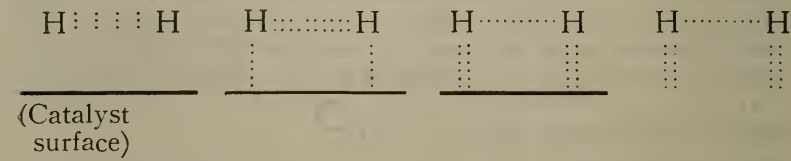
(A). *Reaction between two activated molecules.*



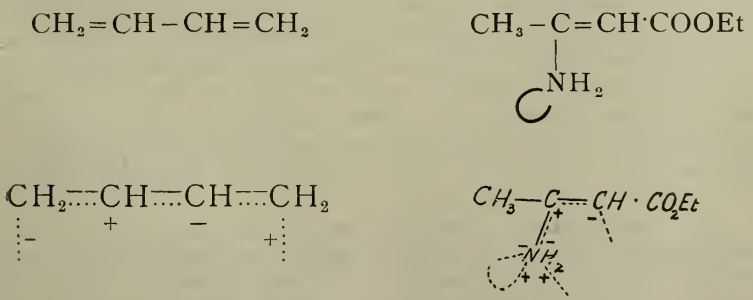
(B). *Reaction between an activated molecule and a neutral molecule.*



In passing it may be remarked that the rôle of a catalyst must very often be to produce activated molecules by the formation and subsequent decomposition of additive complexes. Thus in catalytic hydrogenation the hydrogen may be able to form a loose addition compound with nickel or palladium by the aid of a degree of dissociation so small that reaction with a substance containing an ethylene linkage cannot be effected. This compound on decomposition, however, may be assumed to liberate a strongly polarised hydrogen molecule, which is highly reactive and is capable of direct union with unsaturated substances.

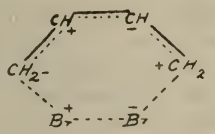


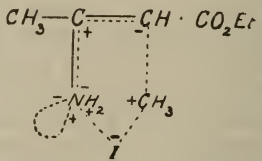
The representation of the phenomena of conjugation and addition to conjugated systems is much simplified by the use of the theory of divisible and polar valency and the definition of a conjugated system may be widely extended when the matter is considered from this point of view. Conjugation is the transfer of a free partial valency to an adjacent atom or to the end of a chain of atoms—it is the explanation of action at a distance in a molecule. The most elementary case may be exemplified by the scheme B above where the disturbance of the valency of a hydrogen atom of methane, due to the proximity of the reactive chlorine, involves the carrying through of this effect to the carbon atom and the appearance thereon of a negative free partial valency. There is clearly no definite limit to this process, but it is certain that the larger the number of saturated atoms in a chain the weaker will be the effect which can be carried through. The facts in relation to the azo-dyes which are substantive to cotton suggest the existence of very long conjugated chains in which all the atoms are unsaturated. A conjugated polarised complex capable of taking part in reactions must clearly have free partial valencies of opposite sign and the chain must accordingly comprise an even number of atoms, the exception being those systems which contain a nitrogen, oxygen or sulphur atom in which part use is made of the latent valencies. The even and the odd membered conjugations are shown below, the examples chosen being butadiene and ethyl β-amino-crotonate.

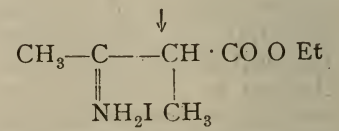


It is convenient to classify as "primary" those conjugated systems or partially dissociated complexes which take part in reactions characterised by addition at the ends of the chain. Thus, in reacting with bromine, butadiene undergoes a

primary conjugation of its partial valencies, and the same is true of ethyl-β-aminocrotonate in reacting with methyl iodide.*







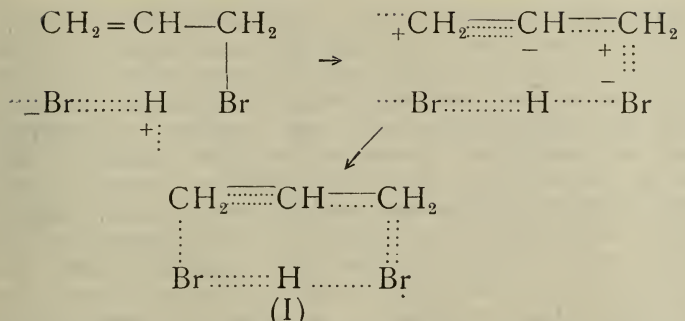
$$Br-CH_2-CH=CH-CH_2-Br$$

It is important to notice that in the series :—initial compounds, intermediate additive complex, final products, all the alterations of valency are progressive. Take, for instance, the bond connecting the two central carbon atoms of butadiene. In the additive complex this becomes a sesqui-valency and a double bond in the product, and a similar gradual change will be found to be true of all the valency rearrangements whether involving making or breaking of unions or the transformation of single into double bonds and *vice versa*. Therefore, by assuming the possibility of great subdivision of valency, all these reactions could be represented as being almost continuous and with many intermediate phases.

The recognition of primary conjugation is rendered difficult when fission follows addition although analogies are usually available to assist in the determination. Thus there can be little doubt, in the author's view, that the facile reactions of aromatic phenols and amines are due to primary conjugations involving the latent valencies of the oxygen or nitrogen in association with the unsaturated carbon atoms of the nucleus. (Cf. G. M. Robinson and R. Robinson, *Trans. Chem. Soc.*, 1917, **111**, 964.)

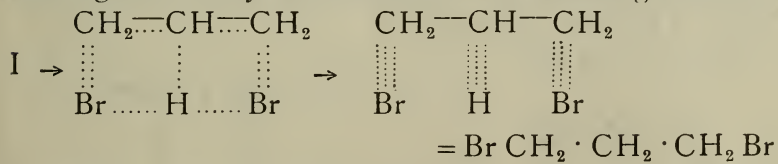
In "secondary" conjugation addition does not wholly occur to the ends of the system and the existence of the condition is usually recognised by an orienting effect. This will perhaps best be made clear by means of an example, the addition of hydrobromic acid to allyl bromide. (− = ⋯⋯).

* This is an unpublished observation made in collaboration with P. W. Denny and for further examples of this type of addition to a conjugated system Cf.—Decker, *Ber.*, 1905, **38**, 2893; Hamilton and Robinson, *Trans. Chem. Soc.*, 1916, **109**, 1029; Robinson, *ibid.*, 1039; G. M. Robinson and R. Robinson, *ibid.*, 1917, **111**, 958.



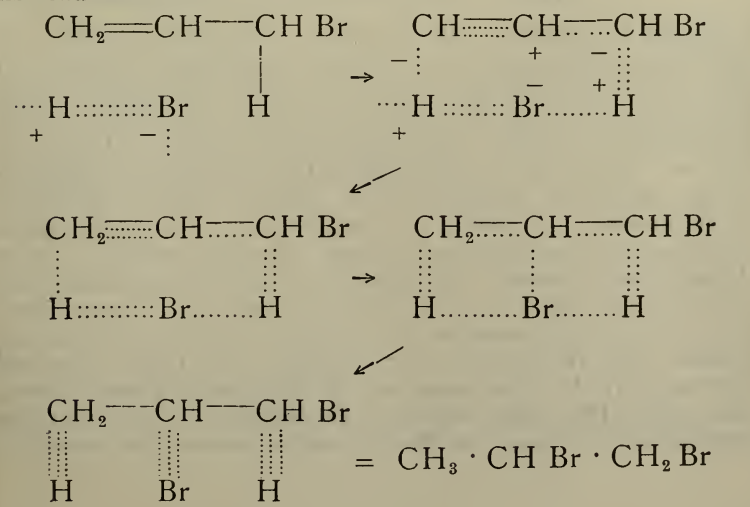
(I)

In the above scheme, the attack of the free partial valency of the hydrogen of hydrobromic acid on the bromine of allyl bromide induces a conjugation resulting in the appearance of a positive partial valency at the other end of the chain. Ring formation follows and the orienting effect is secured since the bromine is already partly attached to the position which it ultimately retains in trimethylene bromide. The further rearrangements may be conceived in the following manner :



$= Br\,CH_2 \cdot CH_2 \cdot CH_2\,Br$

On the other hand one of the hydrogen atoms of allyl bromide might be attacked by the bromine of hydrobromic acid and this leads to a different result as shown below :—

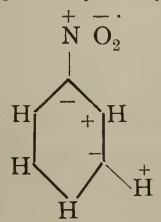


A. F. Hollemann and B. F. H. J. Matthes (*Proc. K. Akad. Wetensch.*, Amsterdam, 1918, **21**, 90) have shown that in bright light allyl bromide absorbs hydrobromic acid with production of trimethylene dibromide, but that in the dark, although the latter remains the main product, considerable amounts of propylene dibromide are also formed. The present writer, in view of the simplification in expression, proposes to adopt the alternate labelling with + and − signs to denote the existence of secondary conjugation, and in accordance with Professor Lapworth's suggestion (this vol., Memoir No. 3, p. 5) the "key" atom may be indicated by an additional dot. Thus to follow out the examples already given, the secondary conjugations involved in the production of trimethylene bromide and propylenedibromide from allyl bromide are:—

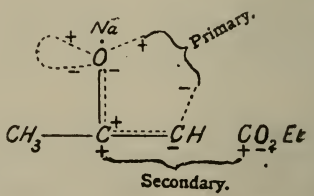
$$\overset{+}{\mathrm{CH_2}}=\mathrm{CH}\cdot\overset{-}{\mathrm{CH_2}}-\mathrm{Br} \quad \text{and} \quad \overset{-}{\mathrm{CH_2}}=\mathrm{CH}\cdot\overset{+}{\mathrm{CH}}\mathrm{Br}-\mathrm{H}$$

respectively. Secondary conjugation is no doubt a widespread phenomenon. It is concerned in meta substitution in aromatic compounds and very frequently also reinforces the effect of a primary conjugation.

e.g.

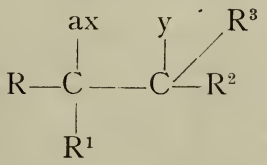


and

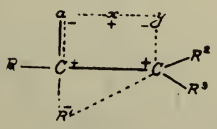


Examples of primary and secondary conjugations could be indefinitely extended, but it is not the present purpose to survey the field of organic chemistry from this point of view, but rather to indicate the general principles applicable to the symbolisation of the mechanism of reactions. There is, however, one group of reactions which occupies a somewhat special position, namely, those which involve molecular rearrangement. A theory of partial valency obviously offers scope for the explanation of such changes, which, it may plausibly be assumed, are in all cases due to an initial ring formation by the aid of fractional valencies. A generalisation of the transformation, of which the change of hydrazobenzene into benzidine is an example, has been discussed elsewhere (G. M. Robinson and R. Robinson, *Trans. Chem. Soc.*, 1918, **113**, 639), and it is of interest to note that the benzidine-type change in the glyoxaline series discovered by

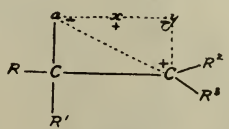
R. G. Fargher and F. L. Pyman (*Trans. Chem. Soc.*, 1919, **115**, 217, 1015) is covered by the general statement and could perhaps have been predicted with its aid. All true intramolecular changes can be similarly generalised and the number of distinct types may be comparatively small. Reference may be made here to the dehydration of pinacone to pinacoline and that of borneol to camphene, two apparently dissimilar reactions which may nevertheless be brought under the same heading. In the expression



R, R^1, R^2, R^3 are neutral groups, *e.g.*, alkyl or aryl groups, *a* is a divalent atom or group and *x*, *y*, are monovalent atoms or groups of such a character that there is a strong tendency to form the compound *xy*. For purposes of convenience (and because it usually is so) *x* will be assumed to have electropositive character and *y* is electronegative. If *x* and *y* become attached by a partial valency then conjugation occurs and we have at once the conditions :—

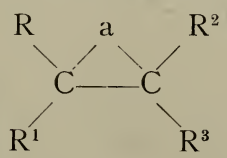


or



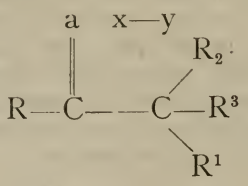
(A) (B)

since ring formation of the partial valencies is clearly impossible unless there are an even number of atoms in the ring. If now the process is continued in the same direction and the compound *xy* is separated, the result will be in case B that a three-membered ring will be formed :—



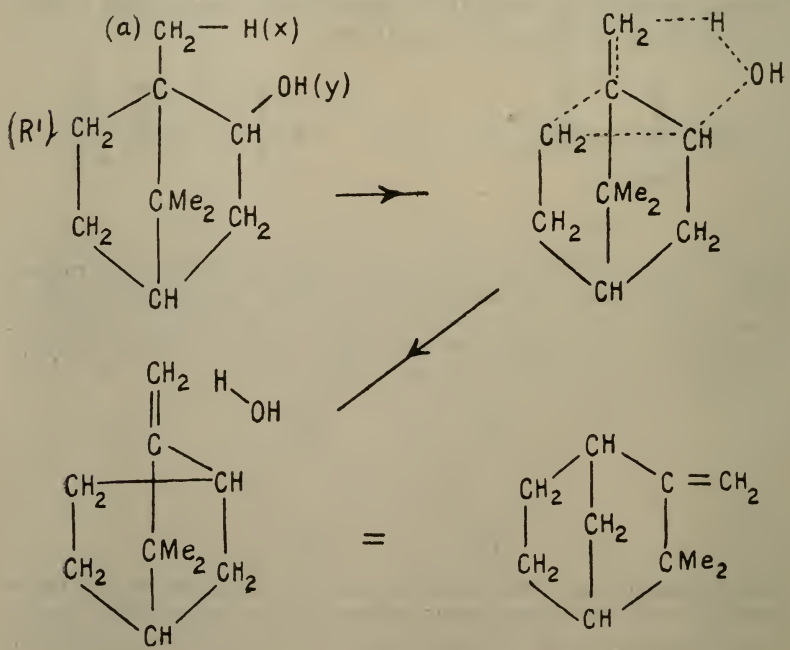
This occasionally happens, but in most cases the structure is unstable and undergoes ring scission under appropriate conditions reverting to the original substance or another compound

resembling it in essential respects. Separation of *xy* from the complex A, however, involves the following result :

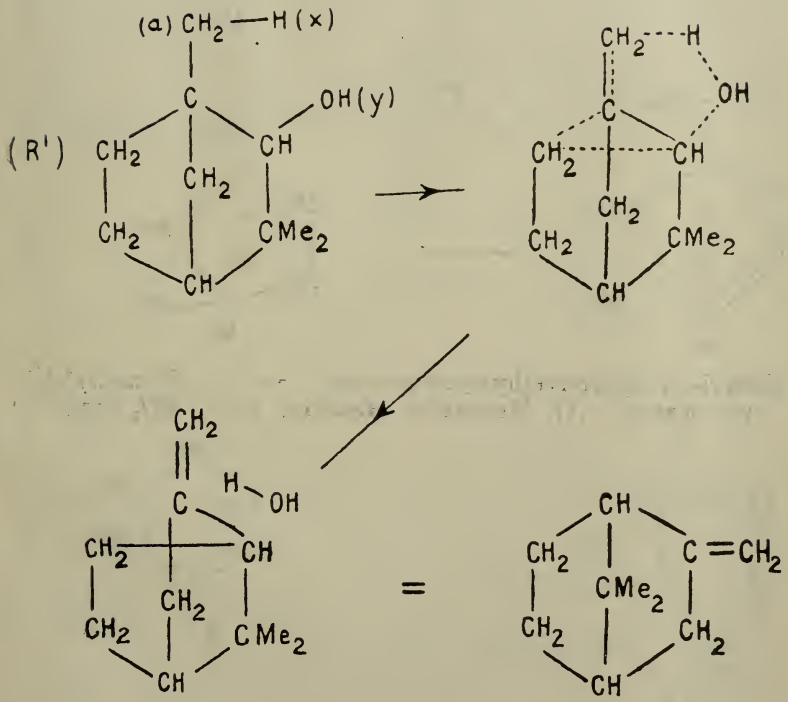


that is, the group R^1 is transferred to the adjacent carbon atom. In the pinacone-pinacoline reaction, *a* is oxygen, *x* is hydrogen and *y* is hydroxyl. In the borneol-camphene or Wagner rearrangement *a* is $-CH^2-$, *x* is hydrogen, and *y* is hydroxyl or a halogen atom. It will be found on inspection that a very large number of molecular changes, particularly in the terpene series, can be brought under the above generalisation. In view of the complexity of the formulæ the following examples may be quoted :—

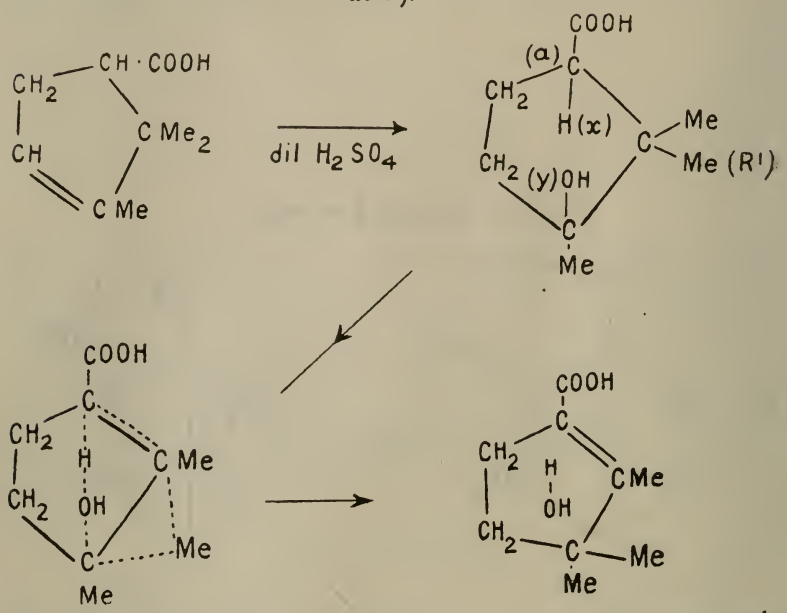
Borneol-Camphene.



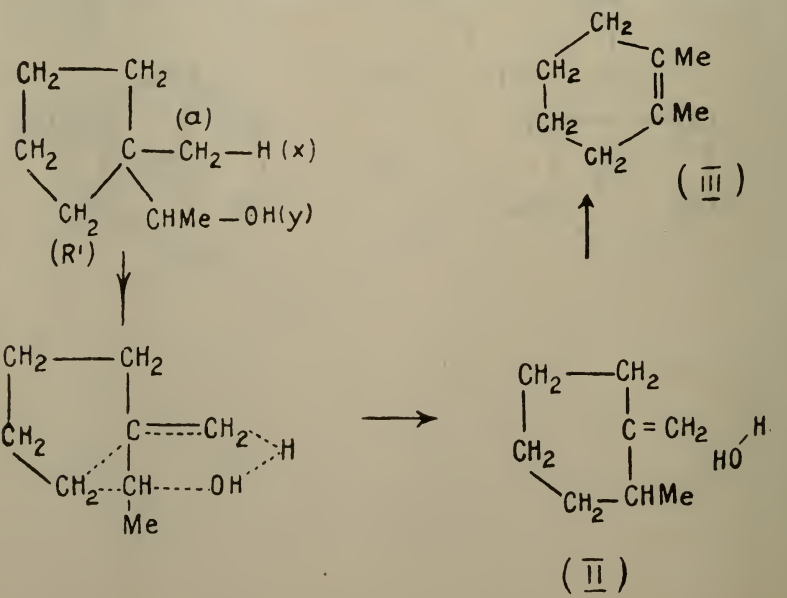
Fenchyl Alcohol-Fenchene.



α-Campholytic acid → β-Campholytic acid (isolauronolic acid).

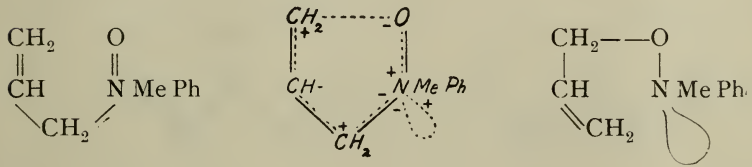


1-Methyl-1-α-hydroxyethyl*cyclo*pentane → 1.2-Dimethyl-Δ^{1}-*cyclo*hexene. (H. Meerwein, *Annalen*, 1918, **417**, 255.)



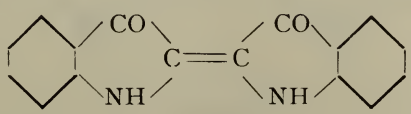
The product should therefore be the exocyclic hydrocarbon (II), whilst Meerwein actually isolates Δ^1-dimethyl*cyclo*-hexene (III). Under the conditions of the transformation the change of position of the ethylene linkage would, however, be anticipated.

Before leaving the subject of molecular rearrangement, an interesting recent observation of J. Meisenheimer (*Ber.*, 1919, **52,** (B), 1667) may be noted. Methylallylaniline N-oxide (IV) on distillation with a solution of sodium hydroxide in a current of steam is converted into the allyl ether of phenyl-methylhydroxylamine (V). This reaction is interesting from the present point of view because, however regarded, it involves the formation of an odd-membered ring. This, as shown below, is rendered possible by the circumstance that a pentavalent nitrogen atom becomes trivalent in the course of the process.

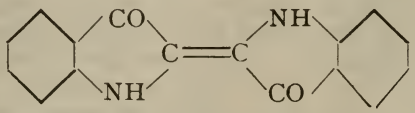


(IV.) (V.)

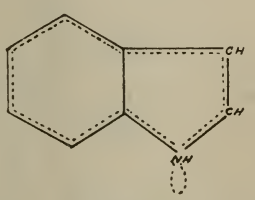
An almost inexhaustible subject for speculation is concerned with the existence of partial valencies and cyclic conjugation of partial valencies in normal molecules as distinct from those which are considered only at the moment of reaction. It has already been pointed out (G. M. Robinson and R. Robinson, *Trans. Chem. Soc.*, 1917, **111,** 964; *ibid.*, 1918, 113, 640; Perkin and Robinson, *ibid.*, 1919, **115,** 943) that the theory of cyclic conjugation of benzene originated by Thiele, combined with a consideration of the part use of latent valencies of nitrogen, affords an explanation of the aromatic character and degree of basicity of pyrrole, glyoxaline, harmine and other heterocyclic types. The extension of such views to even more complex compounds is well illustrated by the case of indigotin, the usual formula of which is of course



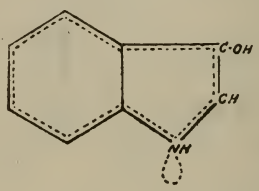
This expression as a vehicle for the explanation of the behaviour of the compound has grave defects, and, since the interpretation of the properties of the carbonyl group is very much a matter of opinion and relations of colour to structure still more so, the criticism of the formula may be confined to its failure to indicate the non-basic character of indigotin and the anomaly of the non-existence of cis-trans modifications. There seems to be no reason why the isomeride,



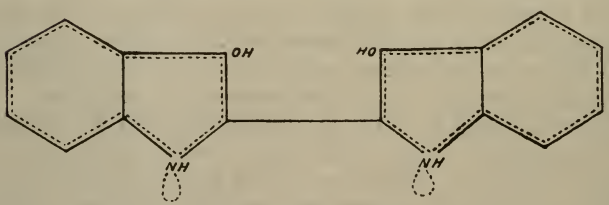
has never been isolated. All these and other objections are completely met by regarding indigotin as a true indole derivative. The series of formulæ now suggested are :—



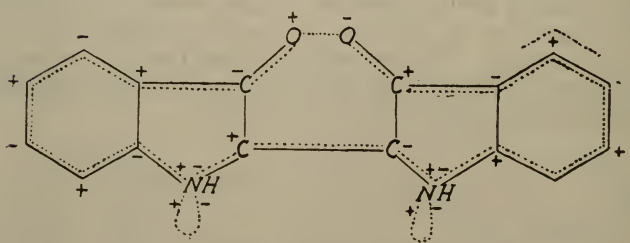
Indole.



Indoxyl.



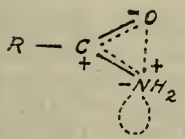
Indigo White.



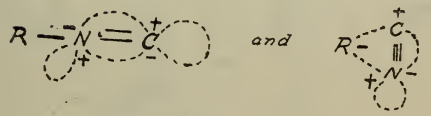
Indigotin.

On this view the oxidation of indoxyl with formation of indigo white resembles the oxidation of β-naphthol to dinaphthol, and the extremely ready reduction of indigotin is well explained by the peroxidic character of the substance. At the same time the nitrogen atoms are not capable of forming stable additive compounds and the possibility of cis-trans isomerism is not indicated. The aromatic cyclic conjugation embraces the whole molecule, the weakest link in the chain being the partial bond connecting the oxygen atoms.

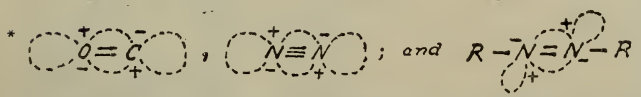
Of other partial valency formulæ the following may be put forward without further comment beyond the statement that the majority represent efforts to indicate the absence of basic properties in nitrogen compounds and that the formula for triphenylmethyl represents the third valency of the central carbon atom as taken up equally by the three nuclei each of which becomes partially quinonoid. Similar formulæ are possible for the rosaniline salts.



for acid amides and similar expressions for the carboxyl group and derivatives.

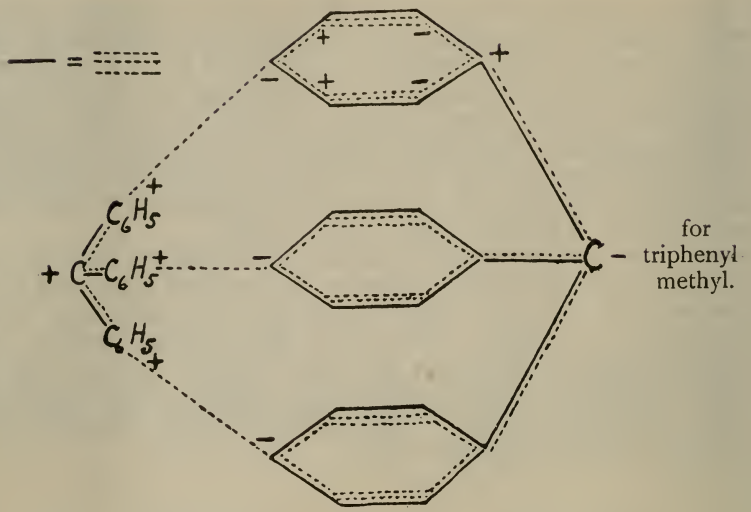


for isonitriles and nitriles respectively.

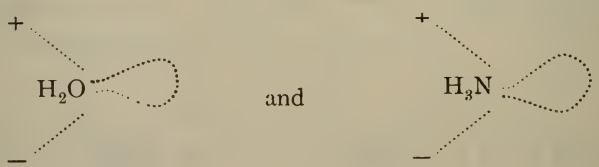


for carbon monoxide, nitrogen & the azo-compounds

*The decomposition, on heating, of ethyl oxalacetate into carbon monoxide and ethyl malonate provides an analogy to the separation of nitrogen from so many azo-derivatives.



The explanation of the nature of loose additive compounds, such as the picrates of aromatic hydrocarbons, on the basis of the theory of divisible valency is so obvious as not to require further elaboration. Water of crystallisation and the ammonia of the metal-ammines no doubt involve the bipolar partially dissociated forms



with the aid of which it is possible to construct formulæ for hydrated salts and the most complex of the compounds now represented in accordance with Werner's co-ordination theory. The author gratefully acknowledges the influence of the writings of Werner, Thiele, Flürscheim, Decker, Kauffmann and particularly Lapworth, with whom he has had the great advantage of frequently discussing these and similar problems.

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31st, 1920).

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Manchester Memoirs, Vol. lxiv. (1921), *No.* 5.

LEGEND
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ADILABAD
NANDER
NIZAMABAD
KARIMNAGAR
MEDAK
HYDERABAD
NALGONDA
GULBARGA
MAHBUBNAGAR
BOMBAY PRES.
MADRAS PRESIDENCY

V. Ancient Mines and Megaliths in Hyderabad.

By Major Leonard Munn, R.E.

(*Communicated by Prof. G. Elliot Smith, M.A., M.D., F.R.S.*)

(*Read February 5th, 1918. Received for Publication December 31st, 1920*).

The object of this paper is to record some personal observations relating to the occurrence of dolmens, stone circles, and ancient mines, within the territories of H.H. the Nizam of Hyderabad.

In my capacity of Inspector of Mines to the State, I have had an exceptional opportunity of touring over and observing this country during the last 13 years.

The problem of the dolmens and stone circles is receiving the special attention of the Hyderabad Archæological Society, who will from time to time, in their journal, publish any new discoveries; so I will only attempt to plot on the attached map the position of the various groups of tombs known up to November 1915, and indicate the sites of the various classes of old workings.

The State of Hyderabad is about the size of Italy, and the dolmen remains, in comparison with the number of the cairns, are probably relatively scarce. I believe that the Bellary and Dharwar Districts, to the South of the Kristna River, will be found to contain many more dolmens than the whole of Hyderabad. Colonel Meadows Taylor reports 2,127 in Bellary District alone. Both these districts are riddled with old workings for gold, copper and iron.

The circled cairns, which are scattered in groups, sometimes numbering a few, sometimes thousands, all over certain geological areas of the State, are always found covering cists, containing uncremated and exceptionally well preserved human remains—iron implements—black and red pottery, sometimes of high finish but not decorated like that of the Nilghiris,—occasionally a bronze bell or a copper dish, and in rare instances, beautifully pierced beads of carnelian or *lapis lazuli*.

February 28th, 1921.

The stone circles are frequently found around the base of the "dome-shaped" protrusions of granitoid gneiss, which form such a noticeable feature of the Deccan Plateau, and apparently from all time have been held in reverence.

In all probability the cists, as Dr. Hunt observes, originally contained no filling—the silt which they now contain, the "Pandre-mutti" referred to by Colonel Meadows Taylor, being, no doubt, the result of infiltration of mud during successive monsoons. They are sometimes divided longitudinally into separate compartments, each containing a body.

Personally I have never come across any instances of burial such as Colonel Meadows Taylor found at Jewurgi, which led him to infer that human sacrifices were sometimes practised.

The manufacture of iron in the Deccan seems to have immediately superseded the Stone Age, the general use of high-class bronze and copper articles, some of which were found at Jaggayapet, in a grave, mixed with the bones of a horse, seem to be the product of a later age. The iron implements so far recorded, are spear heads, swords, sickles, iron stands for pots, and lamps. A careful analysis of some of these articles might afford an explanation why some implements have remained so wonderfully preserved, whereas others have become entirely unrecognizable through oxidation, though buried in the same grave.

In plotting the attached map I have classified all dolmens (whether circled, or free standing cromlechs or kistvaens) together, and used a separate symbol for cairns, whether with single, double, or triple circles. Even with the knowledge at present at our disposal, my map, I think, shows how closely they are associated with the sites of ancient mines.

There is little doubt that the plough is fast removing all these remains, and this perhaps explains why we generally find them on unculturable land.

No further discoveries of dolmens in the Raichur or Shorapur Districts have been recorded, though I am able to plot various localities where I have noticed stone circles, but which yet remain to be examined.

In 1904 I found a large group of dolmens of the open cromlech type at Chintrala in the South-East of the State, near the banks of the Kristna River, clustered around some old copper workings which I was examining. I reported them to the late Mr. Bruce Foote, and opening one, to find pottery and ashes, I took no further steps; and the group remains to-day untouched.

The local Brahmins raised no objection to my examining these graves, which they said were the homes of Rakshasa who were slain by Rama.[1]

Near the dolmens were what I took to be hut circles.

In the jungle near by, and all along the banks of the Kristna, are old diamond washing tanks, and heaps of river bed pebbles which had been carefully sorted in the method described by Tavernier.[2]

Further in the jungle I found some old terraces, showing previous long forgotten irrigation, of which there was no record on the Putwari's books.

So far as we know at present we have the following types of megalithic monuments :—

Dolmens.	Free standing dolmens.
	Holed kistvaens.
Circles.	Circles around cairns with internal cists.
	Circles around cairns with summit cist and internal cists.
	Circles around dolmens.
	Circles around menhirs or natural poised rocks.
	Stone alignments.

It must not be thought that the attached map, in any way, defines the limits of the megalithic remains, or the ancient mining and smelting areas of the Deccan, save for spots I have personally visited along the borders of the State, I have confined myself to the area under my supervision.

1. My Brahmin clerk told me that one caste of blacksmiths still bury the cremated ashes of their dead in stone cists.

2. From this spot the cruciform shape of the quartzite ridge on the south bank of the Kristna below Mugetalah, mentioned by Tavernier, stands out with great clearness, and should remove any doubt as to which village is the Gani Kollur, to which he refers.

The geology of H.H.'s State can be divided into the following five main groups, which alone I have shown on my map; and for the sake of distinctness I have not attempted to outline the subdivisional groups.

*1. Archæan.	(*a*) Granite, granitoid gniesses veined with dykes of newer intrusive rock. Beds of iron ore	Prehistoric iron mines over the entire area.	
	(*b*) Dharwar Schists composed of hornblende and chloritic schists and epidorites and bands of hæmetitic and magnetite schist.	The gold bearing rocks of Southern India. Iron worked on the hæmatitic schists.	
*2. Puranas (Vindhyan Rocks).	Limestones, quartzites, sandstones, slates and conglomerates.	The diamond and copper mines of Southern India.	
3. Gondwana Series.	Sandstones and lacustrine coal beds resting on a glacial boulder bed.	Iron ores from each subdivision have been smelted. The area is mostly covered with dense forest.	
*4. Deccan Trap and inter-trappean Beds.	The result of an enormous volcanic outburst in late cretaceous times which covers 200,000 square miles of India—during long quiescent period fresh water beds formed and were in turn covered by the trap.	Surface soil unsuitable for irrigation, remarkably few megalithic remains.	Area covered with tank irrigation.
5. Cainozoic.	(*a*) Laterite.	Worked for iron.	
	(*b*) Alluvial beds	Washed for diamonds in all streams and rivers which traverse the diamondiferous beds of the Purana series.	

* See Sir Thomas Holland. "Gazetteer of India," Vol. I

GOLD.

The area covered by the Dharwar Schists not only in Hyderabad State, but from Shorapur in the North, to the Wainād in the extreme South of India, is everywhere pitted with the remains of ancient gold mining, and, as far as I personally have seen in Hyderabad, around or in the vicinity of these workings, dolmens and circled cairns are to be found, and in Dharwar and Bellary even greater quantities are reported.

As far as Hyderabad State is concerned, the memory of the ancient gold mines and their workers seem entirely lost. I believe that this is true of the rock workings of Kolar, Dharwar and Rhodesia goldfields, though desultory washing for alluvial gold is recorded.

In Hyderabad one can obtain some idea of the possible date only through a process of elimination.

It cannot be possible that any gold mines existed in the days of the Vijjianuggur Kings, the wealth of whose kingdom was extolled by Ferishta, for sufficient time would not have elapsed to allow for the complete filling up and entire obliteration of all surface indications, of the huge pits which have since been unearthed, even if all memory of such an industry could be effaced in such a relatively short period. This is most unlikely, for the present inhabitant readily points out the iron mines, which still remain open, and records prove to have been worked at that period. Besides, the Raichore Doab has not been without its European Chroniclers, and neither Ferns Nunez or Paes ever mention the existence of gold mining. Nor in the great store of copper plate—or lithic records—which range through Mahommedan Chalukqan, back to the newly found inscription of Asoka, carved on a rock at Muski, in the middle of the auriferous band and surrounded by old gold workings, do we find a single reference.

Of folk lore there is none, else it must have come to the ears of Colonel Meadows Taylor, a man so loved and respected that his name yet lingers among the villagers and is recorded in song, which may still be heard, croned by some Beydur mother as she hushes her infant to sleep.

But beyond Professor Lassens' statement that the Sanskrit words, used in the Bible, had a Deccan termination, and on which he assumed that the land of Ophir was on the Malabar Coast, and that apparently unsatisfactory process of dissecting place names of the Doab, starting with the Sanskrit "Hoon" and generally terminating with either Persian or Canarese, no evidence of any gold industry can be found

save a casual remark in Pliny ("Nat. Hist.," Book VI, chap. xx.).

It was, in fact, not until after 1888 that these old gold mines were rediscovered, and the early efforts of the explorers were watched with intense ridicule by the local Brahmin—who never had had clearer proof of the Sahib's madness. The difficulty which attended this prospecting was accentuated by the fact that all the workings had been completely filled up, and practically obliterated by the so-called black cotton soil—an alluvial resulting from the decomposition of the Deccan Trap. So that the surface indications were most deluding and consisted of shallow depressions, associated sometimes with chips of typical auriferous blue quartz, and the remains of old metallurgical appliances on the adjacent hard Trappoid rock. Costly excavations, therefore, alone could tell whether the site chosen was a series of rabbit warren workings, where the ancients followed some rich quartz leader, or whether a valuable pay chute was going to be disclosed.

The obliteration of all surface indications has been most tantalizing, and although the industry is represented at the moment by only one working mine, my confidence in the future discovery of other payable gold mines hidden below the black cotton soil plain is in no way shaken.

At Wondalli, Topaldodi, Oti Budini, Muski and Shorapur excavations of great age were opened up by the Hyderabad Deccan Company and its subsidiary companies. In each instance the ancients had extracted all payable gold to a considerable depth, and their methods of crushing were evidenced in the large grinders or rollers of hard trappoid or granite, which was rolled backwards and forwards in large hollows or saucers in the trappoid rock.

One of these "Mullackers" at Wondalli nullah must have weighed a ton, and was probably actuated by poles lashed to it. Everywhere cup-like hollows, undoubtedly nothing but small mortars found in the rock where the gold quartz was pounded with stone pestles and occasionally small crucibles have been found which, on crushing, gave an assay for gold.[3] Whether the miners possessed the knowledge of amalgamation is a moot point.

In the Hutti gold mines, discovered by Mr. F. W. Grey, we have the most extraordinary evidence of the skill of these ancient workers. There was little surface evidence at Hutti—

3. I have often wondered whether some of the "cup markings" reported by archæologists are not identical with these, and originally used for the same purpose. The Indian ryot recognises what they are, and even to-day uses them if they happen to be near his field.

a slight series of depressions—and here and there a few splinters of quartz which gave an assay—and the usual marks of crushing on the hard trappoid rocks near the Hutti nullah. Cross cutting exposed a long series of workings which were not bottomed by means of a small exploratory shaft. The Company was formed and deeper mining on a larger scale was undertaken, but the first attempt failed to bottom the old workings. Finally it was proved that the ancients had excavated all payable quartz to an unparalleled depth of 640 feet. The presence of explosive gas—no doubt due to rotting timbers—and the expense that spilling through the loose material in the old stopes would have cost prevented any extensive exploration of the old mine.

Sufficient evidence was found to state that the quartz reef was extracted by fire-setting—and after it was loosened was gouged out by iron-shod wooden levers. A great amount of timber had been employed; one piece might have been a windlass and marks on the "hanging wall" suggested the ore was raised by means of ropes. It was probably water that finally stopped the old workers from going deeper, for at 640 feet a large quantity of broken "chatties" were found, which suggested heavy bailing. No such instance of perseverance and skill has so far as I know been ever discovered in the other ancient mining centres at Kolar, Wainād, Dharwar and Anantagiri. The development of this mine must have taken a considerable period and employed a great number of people, not only in the actual mining, but in the crushing of the resulting ore.

I should like also to mention the ash mounds at Wondalli and Machnur. For a long time speculation attributed them to the slag, resulting from the refining of the gold or from glass making. Captain Newbold, who noticed some others near the so-called copper mountains, near Bellary, thought they were the remains of funeral pyres, and Mr. Maclaren, whose reports for the Geological Survey are so full of interest, gives the following assay, which he thinks upholds this theory.

	%
Moisture	0.26
Loss by ignition ...	3.39
SiO_2	66.19
CaO	15.88
Fe_2O_3 and Al_2O_3 ...	8.19
P_2O_5	1.57
Undetermined ...	4.52
	100.00

The Wondalli heap measures 150 ft. by 110 ft. by 25 ft. high and must contain 375,000 cubic feet, and is smaller than the one at Machnur. The mass is dull white to brownish in colour and here and there shows a certain amount of fusion.

It is unnecesary for me to give references to the Aryan habit of huge sacrifices, or to mention the custom of burning the dead on the battle field, but these mounds are of such enormous size that it is incredible that this could have been their origin. A few stone circles exist in the vicinity.

DIAMONDS.

Diamonds seem to have been worked in the Deccan from the earliest times, and it is only needful to mention the name of the old Hindu Capital Golconda (Kala Kandar) to recall the fame of the industry.

The diamond workings are of two classes—mines in the quartzites, sandstones and conglomerates of the Purana Group, and alluvial in the beds of rivers and streams which traverse those rocks.

It seems to be generally acknowledged[4] that India was the original source from whence the diamond came to the west and continued as the main supplier until the finding of the Brazilian mines.

As regards the ethnology of the miners, there is nothing to connect the earliest workings with Aryan influence; though in later times the Dravidian tribes became to a certain extent merged into the Hindu caste scheme—the industry remained in the hands of these outcasts to the present day.

On the accompanying map will be found most of the places made famous by Tavernier; besides those are marked some other spots where both alluvial and traces of pits, probably sunk in search of diamonds, have been noticed.

COPPER.

The large area of old copper workings, both in Hyderabad State and bordering the State to the South, are scattered over an area of apparently very low grade cupriferous slates. These workings were always a puzzle to me, until I hit upon the secret, by finding the village Dhobi at Chintrala beating out his Dhotti's on a slab of practically pure melaconite.

The ancients (at any rate in my district) carried out most extensive rabbit-warren-like workings in search of these pockets of high-grade ore, the product of surface enrichment.

4. See B. Laufer's report on "The Diamond in the Field." Columbia Museum (Chicago) reports.

I was able subsequently to find some of these pockets and some beautiful specimens were sent to the Madras Museum.

I found no trace of any smelting furnace, but saw a considerable amount of slag.

The copper mining in Hyderabad State in and around Chintrala is certainly very early, and, as I have already mentioned, so intimately associated with dolmen remains that, even in 1908, I had connected the two things together and never found them apart.

Iron.

Unless anyone has visited Hyderabad State, or in fact Southern India, they cannot get even a slight idea of the abundance, the extent, or the pureness of its iron ores. No section of the geological sequence exists in which iron does not occur. In the Archæn, magnetite most frequently occurs in almost unparalleled magnitude, whole hills and ranges being formed of the purest varieties; specular iron and red hæmatite are also found. The schistose area contains interbedded layers of magnetite and hæmatitic schists. The Purana Group contain veins of limonite and bedded magnetite. Nearly every group of rocks in the Gondwana system, save the bottom glacial beds, contain one or more of the ores of iron, in greater or less quantities. The disintegration of the Deccan Trap supplies rich pockets of magnetic iron sand that glisten in the beds of every stream that traverse that area.

Lastly the laterite is noted for its richness in this metal.

Each and all of these ores have been used for smelting iron by the natives. In this area iron has been known from earliest times, and the unintentional manufacture of steel practised.

Iron being found in such abundance on the surface, I cannot define any actual prehistoric mines, but the following centres of the industry have been always famed throughout India :—Nirmal, Hanumkonda, Warangal, Medak, Elgundal, Anantagiri, Nizamabad, Mudgal, Dekarkonda. They are indicated on my map. Of those I have mentioned, Nirmal is undoubtedly the most famous. Here steel has been made for unknown ages, and it has been a great trading centre for "wootz," right up to the nineteenth century, when Dr. Voysey found a Persian trader there from Ispahan purchasing the steel.

"The ore of this locality," writes Malcolmson (*Trans. Geol. Soc.*, Vol. V), "must be of exceptional quality, as otherwise it could not have retained its reputation as the best material for Damascus blades." It is near this village that

Fergusson notes some Christian crosses, lying near the dolmens. If he had only realized what a famous trading centre Nirmal District had once been he would have no difficulty in accounting for them.

Paithan in this district is mentioned by Herodotus.[5]

The Gondwana Series is contained within a long strip of country running parallel to the eastern boundary of the State. Save for a portion around the modern coal mine of Singareni it is almost unknown forest. Mr. Wakefield, the Director General of Revenue to H.H. The Nizam, has told me of wonderful old irrigation schemes, now out of use, within this region, and I have found areas of slag, proving old iron smelting sites, but I have never found any circles or dolmens. As soon as the war is over the revision survey of this area will be continued by the Government of India Survey, and it would be a wonderful opportunity to get, if they exist, the cairns and dolmens recorded, as well as those occurring in the remainder of Southern India.

The Deccan Trap contains no minerals of commercial value. It stretches over the whole northern and western portion of the State. At Tuljapur, Colonel Meadows Taylor reports a group of cairns near a rock temple, all associated with cremation, but beyond this I am unable to tell you of any other megalithic monuments situated within the geological area. Once the border between the Archæan and the Trap is passed the soil changes, and the black argillaceous soil of the Trap country is unsuitable for irrigation, which in this area is uncommon. The Trap area contains all that wonderful series of rock-cut temples—Ellora, Ajunta, Aurungabad, Nasik and Elephanta; and although these are of a later date than the monuments we are discussing, it is curious to note the Buddhists and Brahmins have each in turn chosen this rock in which to develop these marvels.

Before reading Professor G. Elliot Smith's and Mr. W. J. Perry's memoirs (in the *Memoirs and Proceedings* of this Society), having been so long accustomed to seeing terraced irrigation everywhere in Southern India, I had always taken it for granted that it was the natural product of a country whose total rainfall is limited to a few months of the year, whose surface contours make tank construction easy, and

5. About four years ago, the Taluqdar of Nizamabad sent to my office some fresh water pearls, collected from a mollusc in the fort ditch of Nirmal. I sent some of the shells to the Natural History Society of Bombay. I have never come across any other instances of fresh water pearls in the Deccan, and wondered at the time whether they could have been imported there at some period.

whose soil is specially suited to this class of agriculture. It is true that I had realized that this practice is practically unknown in Mahratwarra country to the north, but that is due to unsuitability of the Deccan Trap soil. Beyond this area to the north, where the Puranas and Archæan again appear, the custom of tank irrigation is not so prevalent. Irrigation is not a subject I am competent to discuss, but from my own observations I can state that here and there in the jungle are to be found remains of terraced irrigation of unknown age, well away from any village sites, and yet in no way differing from that still in use.

BIBLIOGRAPHY.

DIAMONDS. Ain-i-Akmari, Gladwin's Translation.
Ball. "Manual of the Geology of India," Part III.
Ritter, Karl. "Erkunde Asie." Vol. vi, p. 343.
Kings, C. W. "Precious Stones, Gems and Precious Metals." Bell and Daldy, London, 1865.
Jules, Col. "Marco Polo," Vol. ii.
"Mani Mala, a Treatise on Gems mentioned in Hindu Puranas, etc." By Raja Sourindro Mohun Tajore. Calcutta, 1879.
Kern, H. *Journ. Roy. As. Soc.*, Vol. vii, N.S., 1875. A translation of Brhat Sanhita.
Foote. "Southern Mahratta Country." *Mem. G.S.I.*, Vol. xii.
"Tavernier's Travels." Ball's Translation. 2 Vols.
Ball. *Journ. As. Soc. Bengal*, Vol. l, 1881.
Heyne's Tracts.
Voysey. *Asiatic Research*, Vol. xv; *Journ. As. Soc. Bengal*, Vol. ii.
Walker. *Madras Journ. of Lit. and Sci.*, Vol. xv.
Newbold. *Madras Journ. of Lit. and Sci.*, Vol. iii.
Malcolmson. *Trans. Geol. Soc. London*, Vol. v, 2nd ser.
—— Pamphlet addressed to Earl Marshall the Duke of Norfolk in year 16—.

IRON. Foote. *Mem. G.S.I.*, Vol. xii. (Cont. illustration of furnaces.)

GENERAL. Buchanan. "Journey Through Mysore," Vols. i and ii.
Heyne's Tracts, pp. 218, 225.
Blandford. *Records G.S.I.*, Vol. iv, p. 114, and Vol. v, p. 20, with description of furnaces.
Malcolmson. *Trans. Geol. Soc. London*, N.S., Vol. v.
Voysey. *Jour. As. Soc. Bengal*, Vol. i, p. 245; Vol. ii, p. 402, with description of furnaces and smelting.
Indian Review, Vol. vi, p. 563, gives description of furnaces, etc., at Hanumkondah.
Walker. *Madras Jour. of Lit. and Sci.*, Vol. xv, and Vol. xvi, re. Medak, Elgundal, Warangal, Nizamabad, Lingampully, and other centres.
Fergusson. "History of Indian and Eastern Archæology."
Ball. "Manual Indian Geology," Part III.

General Meeting, January 20th, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Mr. THOMAS HORNER, M.Sc.Tech. (Manc.), A.I.C., Chemist, 9, *Elm Bank, Humphrey Street, Crumpsall, Manchester;* Mr. SAMUEL KERSHAW, L.D.S., Dentist, 167, *Cheetham Hill Road, Manchester;* Miss DOROTHY GLADYS COWARD, M.Sc., Headmistress of the Broughton and Crumpsall High School, Manchester, *The Broughton and Crumpsall High School, Manchester;* and Mr. SYDNEY H. HIGGINS, M.Sc., Chief Research Chemist, The Bleachers' Association, Ltd., Manchester, *The Research Department, The Bleachers' Association, Ltd.*, 4, *Norfolk Street, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, January 20th, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books on the table. These included "*Cheap Steam*," vol. 3 (4to., London, 1919), presented by Messrs. Edward Bennis & Co., Ltd.

A valuable gift by Mr. HENRY BODDINGTON, J.P., of Pownall Hall, of a portrait of Henry D. Pochin, one time Mayor of Salford, in his chemical laboratory, was exhibited at the Meeting; and it was unanimously resolved that the best thanks of the Society be accorded to Mr. Boddington for his generous gift.

Professor W. M. CALDER, M.A., read a paper entitled

"Geography and History in the Mediterranean."

Professor Calder described in detail the relation of the Mediterranean as a whole to the series of great plains lying to its north and south, and to the mountain systems known as the "roof of the world," running from the north of India to the Eastern Mediterranean, and reappearing in Greece, the Alps, the Pyrenees, and the Atlas mountains in the north of Africa.

After explaining how the main geographical features of the countries bordering the Mediterranean had influenced the development of their communications and trade and the growth of their states and institutions, Professor Calder showed that the group of routes entering the Mediterranean area came from the raw material producing districts in Central Asia and the Monsoon Countries, and down the valley of the Nile from Equatorial Africa. In the Mediterranean area these routes met the great roads passing into Northern and Western Europe A great deal of ancient history coincides with the varying degrees of importance of these routes. In the eastern part of the

Mediterranean lay the greatest route in history, leading from the Persian Gulf to the Levant, generally called the Cilician Gates route. This route had western extensions which, passing through the body of Greece, had raised to importance the cities of Athens and Corinth, but which later, with the development of sea-craft, left Greece alone, and passed straight from the Levant to Italy and the West.

With the growth of European civilisation, the western extension of this route has swung round towards Western and Central Europe, and it has recently caused the world a considerable amount of trouble in the guise of the Berlin-Baghdad Railway. A railway running from Central Europe to the Persian Gulf is enormously important in itself, and its importance is increased by the vast areas which will one day be "tapped" by its extensions. Near Aleppo there already exists a railway junction whose political importance staggers the imagination, the junction of the future for London, Berlin, Calcutta, Cairo, and Cape Town. "Rail power" may one day restore the Levant to its ancient pride of place as the centre of communications of the Old World.

General Meeting, February 3rd, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Mr. ALBERT ALFRED BUSS, F.R.A.S., Engineer, "*Barrowdale*," 22, *Egerton Road*, *Chorlton-cum-Hardy*, *Manchester*, was elected an Ordinary Member of the Society.

Mr. CHARLES W. SUTTON, M.A. Chief Librarian of the Manchester Public Libraries, 323, *Great Clowes Street*, *Higher Broughton*, *Manchester;* Mr. WILLIAM SALVADOR CURPHEY, F.I.C., Chief Alkali Inspector, 87, *Canfield Gardens*, *Hampstead*, *London*, *N.W.6.;* and Mr. J. T. F. BISHOP, Retired Engineer, Honorary Secretary of the Manchester Chemical Club, 1890—1916, *Byways*, *Ayres End*, *Harpenden;* were elected Corresponding Members of the Society.

Ordinary Meeting, February 3rd, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Professor EDMUND KNECHT, M.Sc.Tech., Ph.D., F.I.C., read a paper entitled **"Alpine Insolation Effects on Unprotected Wood."**

The author described a number of observations which he had made on the effect of direct sunshine on the wood of the Alpine log-huts or chalets, particularly in the vicinity of Villars sur

Ollon. A distinct change of colour in the exposed parts began after about 3 years after which a rich brown began to develop. This was followed after an average period of about 30 years by a blackening of the surface. When exposure had lasted a hundred years or more the whole of the exposed surface was sometimes charred or scorched to a uniform black, which presented under the microscope the appearance of coal, but the charring did not penetrate far below the surface. The fact that the sun's action was more marked on the western than on the eastern aspects appeared to indicate that the changes were brought about more by thermo-chemical than by photo-chemical action. The maximum temperature recorded by the black bulb thermometer in these Alpine altitudes was 66° C., which was very much below the temperature of decomposition at present generally accepted (130° C.). By prolonged heating of wood to 93° C. he had succeeded in producing not only browning but even incipient blackening of the surface. Further experiments in this direction were being undertaken but would require a long time for completion. The temperature of decomposition of wood appeared to have an important bearing on the question of coal formation. Incidentally the lecturer mentioned that bleached cotton was more or less profoundly altered by prolonged heating to a temperature considerably below the boiling point of water.

Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., and Mr. HERBERT S. NEWMAN, M.Sc.Tech., read a paper entitled "**On the Behaviour of Amalgamated Aluminium and Aluminium Wire.**"

This paper is incorporated with that read on May 18th, 1920. (See *Proceedings*, 1919-20, p. xxiv.)

Mr. C. E. STROMEYER, Mem.Inst.C.E., M.Inst.M.E., read a paper entitled "**The After Effects of Cannibalism.**"

The author explained that cannibalism would not be indulged in by people with vegetarian tastes nor by people who, having a craving for animal food, could satisfy it, as was the case with the North American Indians and the North Europeans. Others who had this craving but who had no animals to eat, for instance the Fiji Islanders whose largest animals were one rat and five types of bat, would become cannibals. But no state in which indiscriminate man-eating was indulged in could have flourished unless cannibalism was controlled. Officials had therefore to be appointed, and these would invent rites and ceremonies for the protection of their craft. These ceremonies would after a time become religious rites.

This state had been reached in Mexico when the Spaniards arrived; it seems also to have been reached in the Mesopotamian

Empires when domesticated animals were first introduced amongst them. Human sacrifices were to a certain extent discontinued, but the rites were continued. The religious animal sacrifices of the ancients were therefore an after effect of human sacrifices. Even our practice of saying grace before meat and not before drink, though water coming from the skies is more of the nature of a heavenly gift than the meat of animals which have to be killed, may possibly be one of the after effects of cannibalism of 4,000 years ago.

General Meeting, February 17th, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Dr. W. J. WALKER, B.Sc. (St. Andrew's), A.M.Inst.C.E., Lecturer in Mechanical Engineering in the College of Technology, Manchester, *Arbroath, Westcourt Road, Ashton-on-Mersey*, was elected an Ordinary Member of the Society.

Ordinary Meeting, February 17th, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books on the table.

Dr. T. GRAHAM BROWN read a paper entitled "**The Functions of the Brain.**"

The activity of an animal, as seen by an observer, consists in movements of its limbs, changes of its attitude, changes in its expression (movements of the face and of the hair, etc.), and so on. This activity is usually called the "behaviour" of the animal. *In itself* the action of the animal is a physiological one. It may be analysed and described in terms of physiological mechanism. But it is also used as an *index* of the mental processes of the animal. These two manners in which behaviour may be examined—as a thing in itself and as an index of another sort of phenomenon—are not mutually antagonistic. They are complementary, and the facts found by either of them may assist research in the other.

The separate movements of the parts of the body are *integrated* by the nervous system in the total behaviour. This integration may occur at different levels in the central nervous system. At the lowest level—the "spinal level"—the integration is a comparatively simple one. At an intermediate level the integration is a more complex one. The great brain must

be present if the animal is to exhibit all the finer shades of behaviour which characterise the normal animal.

There are two general methods of examination which are used in the investigation of the brain. Of these the first is that of experimental removal of a part of it, and the observation of any subsequent change in the animal's behaviour. The second method is that of stimulation whilst the animal is under the influence of a narcotic. The movements then brought about are studied. The two methods were illustrated by experimental observations; particularly by observations on the physiology of the cortex of the great brain.

When the great brain has been injured by experiment, *paralysis* of a function often occurs. This is seen, for instance, in the paralysis of a limb. A similar state occurs in man after disease of the proper part of the cortex of the brain. A fact of interest in this paralysis is its rapid disappearance in animals. The recovery is not so often seen in the case of disease of the human brain.

These observations on the brain have led to a theory of "cerebral localisation of function" which in its present form is open to criticism. It looks as if the cortex of the great brain is not so essentially necessary to many of these functions as was formerly supposed. It is perhaps possible that a more or less complete mechanism of behaviour is present in lower levels of the nervous system, and that the cerebral cortex is the place where the most complex stimuli (sound, taste, smell, vision, etc.) are compounded together. Their resultant then can affect the lower centres which actually condition the behaviour. The activity of the cortex would then be regarded as one which *directed* the behaviour.

Ordinary Meeting, March 2nd, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books on the table. The Society now subscribes to *Discovery* and *The Journal of Industrial and Engineering Chemistry*.

The PRESIDENT referred sympathetically to the death, on February 27th, of Mr. HERMANN WOOLLEY, who was elected an ordinary Member of the Society in 1918.

Mr. C. L. BARNES, M.A., made a short communication relating to "Einstein's Theory of Space and Time"; and The PRESIDENT and Mr. C. E. STROMEYER took part in the discussion.

Reference was made to a letter in *Nature* of February 12th, 1920, in which the space between the principal focus of a convex mirror and the mirror itself was contrasted with the space outside. If the reflected images of human beings in such a mirror were endowed with intelligence, volition, the ability to measure lines, areas, and so forth, the principal focus, to them, would be at infinity. Equal straight lines, as measured outwards in the direction of a radius would have images of progressively diminishing length in the direction of the focus, but the phantoms would be unaware of this, as their measuring instruments would contract in the same ratio. Other consequences of the distortion were pointed out, and their bearing on Einstein's theory alluded to.

Reference was also made by Mr. C. L. BARNES to the death of Dr. C. GORDON HEWITT, Dominion Entomologist, Canada; a former Member of the Society, well known for his researches on the House Fly, the diseases of trees, &c. The PRESIDENT and Professor Sir WILLIAM BOYD DAWKINS also referred to Dr. Gordon Hewitt and his work.

Mr. W. J. PERRY, B.A., read a paper entitled **"The Search for Gold and Pearls in Neolithic Times."**

Further research on the distributions of early sites of civilisation and of the sources of gold and pearls has produced a mass of evidence to substantiate and enlarge the thesis of a communication to the Manchester Literary and Philosophical Society in 1915 on "The Relationship between the Geographical Distribution of Megalithic Monuments and Ancient Mines." The evidence now suggests that not only megalithic monuments but early sites in general marked the settlements of seekers after gold and pearls; amber and purple having also played their part in attracting strangers. These settlements are mostly localised in the basins of rivers containing gold or pearl-bearing mussels, and the distribution map shows that the early seekers for these objects did not allow much to escape them.

Further inquiry will be necessary in order to determine the precise age when this search began.

Ordinary Meeting, March 16th, 1920.

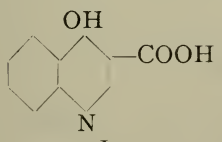
Mr. WILLIAM THOMSON, F.R.S.E., F.I.C. (*Vice-President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table. These included "*Oeuvres Completes de Thomas Jan Stieltjes*" (4to, Groningen, 1918), presented by the Société Mathématique, Amsterdam.

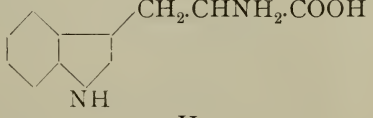
Mr. J. WILFRID JACKSON, F.G.S., and Dr. R. S. WILLOWS, M.A., were nominated Auditors of the Society's Accounts for the session 1919—1920.

Professor ROBERT ROBINSON, D.Sc., F.R.S., read a "**Note on the Mechanism of the Production of Kynurenic Acid in the Dog.**"

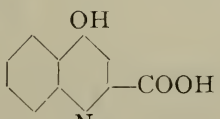
Kynurenic acid was discovered in the urine of dogs by J. von Liebig in 1853 (*Ann.*, **86**, 125), and was identified by R. Camps (*Ber.*, 1901, **34**, 2707) with a synthetically prepared 4-hydroxyquinoline—3-carboxylic acid (I) melting at 266—267°C. A. Ellinger (*Ber.*, 1904, **37**, 1801) discovered that the administration of tryptophane (II) to dogs and rabbits resulted in an increased production of the acid and was led to postulate a relation between the two substances, which his further work soon proved to be erroneous. A. Homer (*J. Biol. Chem.*, 1914, **17**, 509—518) definitely proved that kynurenic acid melts at 288—289°, and identified the acid with 4-hydroxyquinoline-2-carboxylic acid (III), which substance, curiously enough, had also been prepared by Camps (*Ber.*, 1901, **34**, 2712) by the action of aqueous alcoholic sodium hydroxide on the product of condensation of o-aminoacetophenone and ethyl oxalate at 150—160°C.



I.



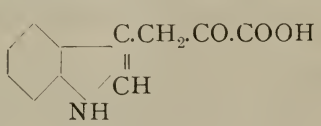
II.



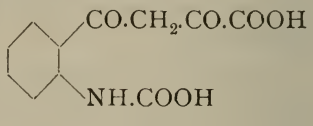
III.

Homer (*J. Biol. Chem.*, 1915, **22**, 391—405) considered that the relation between tryptophane and kynurenic acid might not be direct in the sense that the latter substance is actually derived from the former, but that the metabolic processes induced by the tryptophane might involve the synthesis of kynurenic acid in side reactions. This conclusion was reached partly as the result of an experimental study in which it was shown that the ratio between the tryptophane ingested and kynurenic acid excreted was not a simple one, but depended on the age and condition of the animal and partly because the transformation would involve the enlargement of a five-membered ring. It appears to the present author

that the conversion of tryptophane into kynurenic acid is susceptible of a simple explanation, and that the process is primarily one of oxidation. The first product might well be the keto-acid (IV) which then suffers further oxidation resulting in the fission of the indole ring and the formation of the compound V.

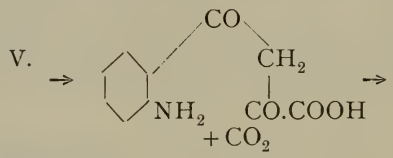


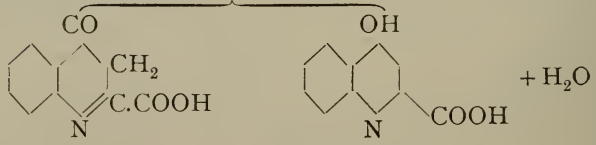
IV.



V.

This hypothetical intermediate, if produced in the laboratory, would beyond doubt be found to yield kynurenic acid when treated with weak alkalies. The necessary changes being hydrolysis of the unstable carbamic acid grouping and closure of the quinoline ring by the aid of one of those reactions which are known to proceed with the greatest facililty, indeed, in many cases, spontaneously. The process is illustrated below.





keto form. *enol form.*

The foregoing suggestion was made by the author in a letter to Professor George Barger, F.R.S., in December 1919, and in February of this year Dr. Barger has informed me that Ellinger has succeeded in preparing the keto-acid (IV) and finds that when this is given to dogs the kynurenic acid formation is increased. This result strongly supports the view which is expressed above.

A paper by Professor ARTHUR LAPWORTH, D.Sc., F.R.S., entitled **"Latent polarities of Atoms and Mechanism of Reaction, with Special Reference to Carbonyl Compounds."** was, in the author's absence, read by Professor Robert Robinson.

Professor ROBERT ROBINSON, D.Sc., F.R.S., then read a paper entitled **"The Conjugation of Partial Valencies."**

These two papers are printed in full in the *Memoirs*.

Annual General Meeting, April 20th, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

Mr. REGINALD FELIX GWYTHER, M.A., Honorary Secretary of the Society, 1888—1897, *Hallcroft, Dufton, Westmorland*, was elected a Corresponding Member of the Society.

Mr. ROBERT ARNOLD WARDLE, M.Sc., Lecturer in Economic Zoology in the Victoria University of Manchester, 7, *Hilton Crescent, Hilton Park, Prestwich, Manchester;* Mr. HUBERT JOHN PATRIDGE VENN, B.Sc. (Lond.), A.I.C., Research Chemist, Messrs. Tootal Broadhurst Lee Co. Ltd., *c/o Messrs. Tootal Broadhurst Lee Co. Ltd.*, 56, *Oxford Street, Manchester*, and *Sunny Bank, Hill Lane, Blackley, Manchester;* Mr. FRANK HERBERT PARKER, B.Sc. (London), Research Physicist, Messrs. Tootal Broadhurst Lee Co. Ltd., 33, *Stanley Road, Whalley Range, Manchester;* Miss DOROTHY ASHTON, B.Sc., A.I.C., Works Chemist, 18, *Randlesham Street, Heaton Park, Manchester;* Miss MARION CHADWICK, M.Sc.Tech., University Demonstrator in Applied Chemistry, *Ingleside, Didsbury Road, Stockport;* Mr. CHARLES CARTWRIGHT, M.A., Accountant, *Pannal, Brooklands Road, Higher Crumpsall, Manchester;* Mr. WILLIAM ERNEST ALKINS, M.Sc., Assistant Lecturer in Metallurgy in the Victoria University of Manchester, *Stoneydale, Ookamoor, Stoke-on-Trent;* and Mr. HAROLD SUTCLIFFE, Assistant Manager, *Kkovah Works, Old Trafford, Manchester;* were elected Ordinary Members of the Society.

The Annual Report of the Council and the Statement of Accounts were presented, and it was resolved :—That the Annual Report, together with the Statement of Accounts, be adopted, and that they be printed in the Society's *Proceedings*.

Miss MARJORIE DRURY and Mr. J. WILFRID JACKSON, F.G.S., were appointed Scrutineers of the balloting papers.

The following Members were elected Officers of the Society and Members of the Council for the ensuing year :—

President : Sir HENRY A. MIERS, M.A., D.Sc., F.R.S.

Vice-Presidents : FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.; R. L. TAYLOR, F.C.S., F.I.C.; WILLIAM THOMSON, F.R.S.E., F.I.C.; R. H. CLAYTON, B.Sc.

Secretaries : H. F. COWARD, D.Sc., F.I.C.; C. A. EDWARDS, D.Sc.

Treasurer : W. HENRY TODD.

Librarian : C. L. BARNES, M.A.

Curator : W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E.

Other Members of the Council : FRANCIS NICHOLSON, F.Z.S.; ARTHUR LAPWORTH, D.Sc., F.R.S., F.I.C.; KENNETH LEE, LL.D.; C. E. STROMEYER, O.B.E., M.Inst.C.E., M.Inst.Mech.E.; W. M. TATTERSALL, D.Sc.; LEONARD E. VLIES, F.C.S., F.I.C.; F. W. ATACK, M.Sc.Tech., B.Sc., F.I.C.; T. H. PEAR, M.A., B.Sc.; WILFRID ROBINSON, D.Sc.

Ordinary Meeting, April 20th, 1920.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S. (*President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Mr. W. J. PERRY, B.A., read a paper entitled :— **"The Origin of Warlike States."**

In a previous communication to this Society, and elsewhere ("An Ethnological Study of Warfare," *Mem. Manchr. Lit. and Phil. Soc.*, Vol. 61, 1917; "War and Civilisation," Lecture at Rylands Library, Sept. 13th, 1918 : The "Megalithic Culture of Indonesia," Manchester, 1918), the theory has been put forward that, speaking generally, warlike states are those with a hereditary military aristocracy. An examination of the ruling groups of the chief historical peoples, Teutonic, Turko-Tartar, Semitic, does not give any signs of their origin in a simpler form of society. The facts suggest their beginning as small groups claiming divine descent. These groups seem to have sprung from the ruling families of a former stage of society which is well known, that called "matriarchal," in which descent in social groups, inheritance to property, succession to rank, went through women, and the chief feature of religion was the cult of the Great Mother. Just after the new groups of rulers had been formed, the institutions had become patrilineal, and the Great Mother was replaced by gods.

The practice of Heraldry is widespread among ruling classes in all parts of the earth, and the study of it gives results which go to verify the theory which comes out of the study of ruling groups; namely, that, all over the world, dynasties have sprung from former ruling classes, and have not sprung up spontaneously in various places. This law of "dynastic continuity," if true, leads to the conclusion that all ruling classes in the world are derived from one original group. This result is in harmony with the claim of Professor Elliot Smith, that all civilisation originated in the Egypto-Sumerian region.

General Meeting, May 4th, 1920.

Mr. WILLIAM THOMSON, F.R.S.E., F.I.C. (*Vice-President*), in the Chair.

Dr. JEAN J. BLOCH, Pharmaceutical Chemist, Manager of the Hollinwood Chemical Co. Ltd., Hollinwood, 400, *Manchester Road, Hollinwood;* Mr. WILLIAM SMALLEY, Engineer, *Springfield, Castleton, near Manchester;* Mr. FRANK WILLIAM BAILEY, Wood Pulp Mill Manager and Chemist, *Lee Mount, Glossop, Derbyshire;* Mr. FRANK BAMFORD, B.Sc., (Lond.),

Chemist, British Dyestuffs Corporation (Huddersfield) Ltd., 42, *The Square, Fairfield, Manchester;* Dr. ARTHUR ERNEST OXLEY, M.A. (Cantab.), Head of Physical Department, British Cotton Industry Research Association, *c/o British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester;* Dr. JOHN CHARLES WITHERS, A.I.C., Chemist, British Cotton Industry Research Association, *c/o British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester;* and Dr. ARTHUR WILLIAM CROSSLEY, C.M.G., C.B.E., D.Sc. (Manc.), LL.D. (St. Andrews), Ph.D. (Würz.), F.R.S., Director British Cotton Industry Research Association, *c/o British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, May 4th, 1920.

Mr. WILLIAM THOMSON, F.R.S.E., F.I.C. (*Vice-President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table. These included "*Slavic Europe, A Bibliography . . .*" by R. J. Kerner (8vo., Cambridge, Mass., U.S.A.), presented by the Harvard College Library.

Mr. W. J. PERRY, B.A., read for Major THOMAS CHERRY, A.A.M.C., M.D., M.S., a paper entitled :—**"The Origin of Agriculture."**

The author showed that the annual flood cycle of the Nile provided perfect conditions for the growth of cereals. Since none other of the great rivers on the banks of which civilisation first appeared affords such natural possibilities for the growth of cereals, it was claimed that man must have learned in Egypt the lesson which the Nile was trying to teach him, that of irrigation and the cultivation of cereals.

The author also discussed the origins of wheat and barley. He claimed that the originals of our cultivated barley probably evolved in the valley of the Nile, while those of our cultivated wheats probably evolved on one of the islands of the Aegean Archipelago.

General Meeting, May 18th, 1920.

Mr. R. L. TAYLOR, F.C.S., F.I.C. (*Vice-President*), in the Chair.

Dr. ALBERT FRANK STANLEY KENT, M.A., Director of the Department of Industrial Administration, The College of Technology, Manchester, *The College of Technology, Manchester;* Mrs. ELIZABETH C. AGAR, 16, *Elm Road, Didsbury, Manchester;* and THOMAS G. RUSSELL, Solicitor, *King Street, Manchester,* and *The Cottage, Lees Road, Bramhall, Cheshire;* were elected Ordinary Members of the Society.

Ordinary Meeting, May 18th, 1920.

Mr. R. L. TAYLOR, F.C.S., F.I.C. (*Vice-President*), in the Chair.

A vote of thanks was passed to the donors of the books upon the table.

Dr. R. S. WILLOWS, M.A., exhibited and described a lantern slide giving a transverse section of cotton fibre, magnified 20,000 times, showing Ball's daily growth rings.

Mr. WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C., read the following paper by himself and Mr. HERBERT S. NEWMAN, M.Sc.Tech., containing further notes on their communication read before the Society on February 3rd, 1920.

"On the Behaviour of Amalgamated Aluminium and Aluminium Wire."

When aluminium wire (that used by us was $^{15}/_{1000}$th of an inch in diameter) is brought into contact with mercury there at once begins to grow from the wire a fine feathery substance which may extend in an hour or two to as much as half an inch or more; this substance is hydrated aluminium oxide (alumina) associated with a small quantity of mercury in the free state.

This observation has been made frequently by others; although we find scanty record of it, and none in the indices of the Scientific Journals to which we had access. Carl Jehn and H. Hinze (*Ber.*, **7**, 1498), on the 11th November, 1874, refer, in a note of a few lines, to aluminium as combining with mercury and forming these curious growths. According to them, after the piece of aluminium had been rubbed with wash leather which had been in contact with mercury, the rubbed surface became warm and dull; and almost instantaneously white tufts began to grow from it to a final length of 3 cm. "These proved to be Al_2O_3."

A reference is made to it in No. 15 of "The Model Engineer Series," Third Edition, page 56, which is a work written to provide "Scientific Amusement." In this the author, Aurel de Ratti, says this phenomenon was discovered by him accidentally in 1895. The aluminium he used was obtained by breaking off a piece from an aluminium pen-holder, in order to obtain a clean and rugged edge without which the experiment would not succeed. He thoroughly moistened the piece and then dipped it into mercury: in a minute or two afterwards small white spots appeared on the sharpest corners and these rapidly grew till they appeared like feathery growths about an inch long.

In his work entitled "The Evolution of Matter," Third English Edition (1907), p. 405, Dr. Gustave Le Bon speaks of "The Transformation of the properties of Aluminium" by its

amalgamation with mercury. He observed that the temperature during oxidation rose to 102° C., that it was the hydrated oxide of aluminium which was formed, that this oxidation took place only in damp air or oxygen, and that an exceedingly minute quantity of mercury effected the complete oxidation of the aluminium. He mentions that he could find no reference to the properties given to aluminium by mercury in any of the most accredited treatises; he consulted the eminent chemist M. Ditte, Professor of Chemistry at the Sorbonne, the author of the most complete and recent work on the properties of aluminium, but he knew nothing of the facts Le Bon had pointed out, who therefore assumed that he was the first to publish anything about it.

We found that for these growths to take place both oxygen and moisture must be present simultaneously. Thus, they will not grow in damp hydrogen or carbon dioxide, nor will they grow in air which has been dried by passage through concentrated sulphuric acid, nor at an elevated temperature of—say—75° C. In damp air containing ether vapour the growths are restricted. They are not formed at all in chlorine gas; and a trace of hydrochloric acid or of ammonia in damp air prevents the growths. Much heat is evolved during the development of the growths. We found the best results to be obtained by amalgamating the aluminium with Nessler's solution, which is an alkaline solution of mercuric chloride in potassium iodide. In such a case 100 parts by weight of wire gave a growth weighing 93.91 parts, the wire left weighing 67.76 parts, so that 32.24 parts of aluminium had become oxidised into alumina, whilst the mercury left in the 67.76 parts of wire amounted to 0.62 part. A neutral solution of mercuric chloride answers this purpose; but the growths are not so profuse as when an alkaline solution is used. If, after passing through the mercuric solution the wire be then passed through a drop of metallic mercury, a still better growth is obtained.

It was observed that the growth never takes place over the whole surface of the wire; but tends to concentrate itself along one side or sometimes two sides of the amalgamated wire when this is lying on a flat surface; whilst in the case of an amalgamated wire suspended freely or fixed upright, 3 lines of growth at angles of 120° from each frequently develop.

When an amalgamated wire is placed for two hours in dry air the mercury originally present on the surface presumably sinks into the aluminium and when the wire is afterwards exposed to damp air no growth takes place.

When aluminium foil is amalgamated and put in water it rapidly becomes converted into the hydrated oxide, which

sometimes assumes a laminated structure exhibiting an iridescent effect resembling Mother-of-Pearl. When this oxide dries it becomes dull white and loses its iridescence.

When exposed to air, amalgamated aluminium foil gives rise to growths; but these seldom assume fine feathery shapes unless the degree of the humidity of the air be suitable. They usually occur as very copious dense growths; and a striking effect is obtained by writing on aluminium foil with Nessler's solution and allowing the growth to develop; when it finally forms white tufts along the lines of the letters.

It is very remarkable that no such growths could be obtained from amalgamated magnesium although this metal undergoes oxidation more readily than aluminium at the ordinary temperature of the air.

"Further Notes on Aluminium Amalgam." 18th May, 1920, by the same authors.

On the 3rd of February last we showed examples of the delicate white filaments which grew out from aluminium wire which had previously been rubbed with metallic mercury or otherwise amalgamated.

These filaments we found to contain mercury and we determined the quantity present in some of the growths from wires amalgamated in different ways.

With a view to find whether the mercury associated with the alumina which constituted these growths was a definite quantity relative to the alumina, we submitted them to analysis and herewith we give the composition of the growths in six different experiments.

PERCENTAGE.

Composition of Filamentous Growths from Aluminium Wire Amalgamated with Nessler's Solution from which the excess of Mercury and liquor was :—

	Wiped off with a cloth.		Wiped off and the wire then passed through dry mercury.			Not wiped, but washed with alcohol and then with ether.
	a.	*b.*				
Mercury	4.55	4.54				20.21
Hygroscopic water (dried over strong sulphuric acid) ... 5.14			70.8	67.5	75.4	
Water (lost at 100°C.) 16.17	30.71	31.82				*61.30
,, (,, red heat) 9.40						
Alumina (Al_2O_3) ...	64.74	63.64	29.2	32.5	24.6	18.49
	100.00	100.00	100.0	100.0	100.0	100.00

* The cooling effect of the ether treatment probably had the effect of condensing an excessive quantity of water on to the wire.

These results show that the alumina growths formed by the presence of mercury on aluminium appeared to carry with them mechanically a quantity of mercury depending on the amount present in excess upon the surface; and that they do not form at all unless such excess exists on the surface.

With a moderate excess the growth is pure white, with a large excess it appears grey, and the quantity of mercury associated with the alumina formed depends on the excess present.

The method of growth appears to be somewhat erratic but in several cases quite interesting. In one experiment we made by incorporating the amalgamated wire with a drop of mercury which had afterwards a perfectly smooth surface, a growth appeared over the whole of the top surface and none on the sides; this growth increased but gradually ceased around the periphery, the central growth continuing till it appeared as a truly-formed inverted cone supported on its apex on the drop of mercury.

On repeating this experiment several times the growths appeared as a profusion of filaments completely covering the globule of mercury and extending for half an inch around it.

Neither pure damp oxygen nor ozone had any effect in accelerating or adding to the profusion of the growths.

The study of the action of mercury on aluminium is extremely interesting as regards the character of this metal; if aluminium be put in water no action is observed, but when amalgamated it immediately decomposes the water liberating hydrogen; when zinc is amalgamated, the mercury tends to resist the action of the water on the zinc and this is still more marked when the amalgamated zinc is immersed in weak acid. Under these conditions it resists the action of the acid but if immersed in its unamalgamated condition the weak acid attacks it at once.

Professor SYDNEY CHAPMAN, M.A., D.Sc., F.R.S., made a few remarks on **"The Lunar Tide in the Earth's Atmosphere,"** in which he pointed out that the atmosphere, like the oceans and the solid earth, is subject to the tidal influences of the sun and the moon. The barometric pressure shows a very minute tidal variation with the period of half a lunar day, this variation being determined only by a difficult process of averaging-out other regular and irregular variations from long series of hourly barometric observations, so that data from very few stations are available. Many questions suggested by the data remain unanswered, but as further data become available, and the theory of atmospheric tides is extended, our knowledge of our atmosphere may become of very great importance.

PROCEEDINGS
OF
THE MANCHESTER LITERARY AND
PHILOSOPHICAL SOCIETY

CHEMICAL SECTION.

Ordinary Meeting, October 24th, 1919.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, in the Chair.

At the Opening Meeting of the newly formed CHEMICAL SECTION of the Society, Professor Sir WILLIAM J. POPE, M.A., D.Sc., LL.D., F.R.S., Professor of Chemistry in the University of Cambridge, gave an Address on **"The Photography of Coloured Objects."**

The ordinary photographic plate is sensitive only to blue and violet light and not to red or yellow. The plate thus receives much the same impression of a parti-coloured scene focussed upon it as we should receive on viewing the scene through deep blue spectacles. The lively discussions concerning the claims of photography as an artistic medium which were fashionable some twenty years ago centred in reality about this limitation of sensitiveness of the ordinary photographic plate; no method of pictorial reproduction which rendered the yellow narcissus and the bright red General McArthur rose as black, whilst showing the violet as white, can be described as artistic. The prime requisite of any photographic process for the representation of parti-coloured objects is obviously that the photographic plate used should be sensitive to light other than the blue and violet; given a plate which is acted upon by light from any part of the visual spectrum many devices become applicable for the production of a satisfactory presentment in monochrome of the coloured object or for the reproduction of the actual component colours.

The first truly scientific appreciation of this principle was stated by Clerk Maxwell, the first Cavendish Professor in the University of Cambridge, who in 1861 exhibited three photographs of a tartan ribbon taken through red, green and blue

colour-filters respectively, and pointed out that the component colours could be reproduced by superposing the three images, each illuminated by appropriately coloured light. Maxwell remarked that "by finding photographic materials more sensitive to less refrangible rays the representation of the colours of objects might be greatly improved." Long after Maxwell's day it was discovered that the ordinary photographic plate can be rendered sensitive to green, yellow and red light by incorporating certain dyestuffs with the material of the sensitive film; previous to the war all the various methods of colour photography—the first of which was devised by Professor Joly, of Dublin—the modern processes of photographic colour-printing, and the present-day panchromatic photographic methods for obtaining a correct rendering in monochrome of parti-coloured objects, were based upon the success which had been attained in imparting sensitiveness throughout the visual spectrum to the ordinary blue-sensitive photographic plate. By staining the plate with erythrosine it becomes sensitive to green and orange; plates so treated are termed orthochromatic. A number of dyestuffs belonging to the class of cyanine dyes discovered by Greville Williams, in 1856, are capable, however, of sensitising a photographic plate throughout the whole range of the visible spectrum. These substances are difficult to make and but little concerning their preparation and chemical behaviour has been published; their photographic applications were carefully studied by several of the large German coal-tar colour firms, and those most suitable for use in colour photography were selected and put on the market under trade names which disguised their chemical identity. At the outbreak of war the Allies were entirely dependent on Germany for these so-called photographic sensitisers; such substances had never been made in this country and but little information as to the identity of the chief sensitisers and their methods of preparation was available. A little acquaintance with scientific photography suffices to show that this situation not only affects such æsthetic industries as those of artistic photography and colour-printing but is also vital to aeroplane photography.

Thus, a distant scene in bright sunlight is always seen to be obscured by a slight haze; this haze is enormously intensified when the scene is photographed on an ordinary blue-sensitive plate, intensified to such an extent that the photographic reproduction of the haze may blot out the whole distant view. The reason for this is that a clear atmosphere is less penetrable by blue light than by light from the less refrangible end of the spectrum. The blue-sensitive plate cannot see far into the distance because of the comparative opacity of the clear

atmosphere to blue light; the eye sees further because it is more sensitive to red than to blue. Obviously, if a distant scene could be photographed in red light only, the picture would reveal much more detail because of the cutting off of the haze owing to the greater penetrating power possessed by red light in a clear atmosphere.

With these considerations in mind the experimental investigation of sensitising dyestuffs was instituted in the chemical laboratories of the University of Cambridge by Dr. W. H. Mills and myself at the end of 1914. Methods for producing the ordinary sensitising dyestuffs on a technical scale were devised, and all the sensitisers used by the Allies have been prepared in the Cambridge laboratories since the German importation ceased. Our photographic air-service was non-existent at the outbreak of war; it was slowly built up until it ultimately became of great magnitude and attained a high efficiency. It started by using ordinary blue-sensitive plates, but at the date of the Armistice some 80 per cent. of the plates used were red-sensitive or pan-chromatic plates.

The best panchromatic plate made in pre-war days possessed about one-third the sensitiveness to red as to blue light. At the present time a very rapid panchromatic plate is on the market which is much faster to red than to blue light; the rapidity of the plate to red light has been thus increased about four-fold. The advantages to be gained by the skilful use of the present highly-perfected panchromatised plates in our photographic air service, in the circumvention of camouflage colour schemes, and in the photography of distant scenes in spectroscopically pure light, are among the most important studies of the new service. The peace applications of panchromatic plates will undoubtedly multiply rapidly. A number of lantern slides were shown illustrating the points referred to above.

The chief processes at present available for the photographic reproduction of the colours of parti-coloured objects were then explained and examples of each were exhibited.

General Meeting, November 28th, 1919.

Mr. R. H. CLAYTON, B.Sc., in the Chair.

It was resolved that the Officers of the Chemical Section be as follows:—R. H. CLAYTON, B.Sc. (*Chairman*); J. H. LESTER, M.Sc., F.I.C. (*Hon. Treasurer*); F. W. ATACK, M.Sc.Tech., B.Sc. (*Hon. Secretary*); and the Members of the Committee:—

Edward Ardern, D.Sc., F.I.C.; H. J. Bailey; Percy Bean, F.C.S.; W. H. Bentley, D.Sc., F.C.S.; Joseph Brewerton; David Cardwell, M.Sc., F.I.C.; H. F. Coward, D.Sc., F.I.C.; J. B. Cullen; R. B. Forster, D.Sc.; W. B. Hart, F.C.S., F.I.C.; H. G. A. Hickling, D.Sc., F.G.S.; Francis Jones, M.Sc., F.R.S.E., F.C.S.; Arthur Lapworth, D.Sc., F.R.S., F.I.C.; T. G. Marsh; S. E. Melling, F.C.S., F.I.C.; F. Lee Pyman, D.Sc., Ph.D.; L. Guy Radcliffe, M.Sc.Tech., F.I.C.; Rona Robinson, M.Sc., A.I.C.; W. Scott Taggart, M.I.Mech.E.; Leonard E. Vlies, F.C.S., F.I.C.; J. A. Weil, and T. Roland Wollaston, M.I.Mech.E.

It was decided that the Officers and the members of the Committee should be disbanded in March next, and that the present Committee should draw up the Constitution and Rules of the Chemical Section for submission to the Council.

It was agreed that all members of the Society should be entitled to attend meetings of the Chemical Section and should receive notices, but any member of the Society desiring to be a member of the Chemical Section should give his name to the Hon. Secretary of the Section.

Ordinary Meeting, November 28th, 1919.

Mr. R. H. CLAYTON, B.Sc. (*Chairman*), in the Chair.

Mr. R. H. Clayton opened a debate on "**The Future of the Chemical Section**;" and he outlined the scheme for the extension of the Society's house to provide further accommodation.

Ordinary Meeting, December 18th, 1919.

Mr. H. N. MORRIS in the Chair.

Mr. HAROLD MOORE, M.Sc.Tech., A.I.C., opened a debate on "**Future Supplies of Motor Fuel.**"

Mr. Moore said:—"In dealing with such a many-sided and highly technical subject as the future supply of motor fuel, it is only possible to give a brief outline of the subject in the time available this evening. I therefore propose to limit myself to giving a rough sketch of the present position.

Until the advent of the internal combustion engine burning

liquid fuels the lighter petroleum products were almost waste products, and were used for heating stills, boilers, etc., and in some cases were even allowed to evaporate away. The actual separation of these volatile products was necessary on account of the flash point regulations dealing with the storage and transport of the heavier petroleum products.

The demand for petrol for automobile engines was therefore readily met in the early days of the petrol engine, though it was necessary to subject the volatile products to the acid and alkali washes known as the refining process. The specific gravity of motor spirit in 1905 was about .690 at 15° C., and it was a highly volatile product. To-day some grades of "spirit" have specific gravities as high as .760.

The import of petrol into this country in 1905 was 18,000,000 gallons, and in 1914, 120,000,000 gallons. The increased demand has been met in the first place by extending the limits of the "cut" for the petrol fractions to include higher boiling fractions. As this produced heavier spirit, and the engines of that day were only capable of utilising highly volatile fractions, the demand would have exceeded the supply if the invention of the jet carburettor had not saved the situation by allowing the use of heavier spirit, and of spirit collected over wider ranges of temperature. Following this development the temperature ranges of the "cut" in the distillation were increased to include both heavier and lighter products, and of recent years the heavier constituents of natural gas have been condensed by pressure and cooling and used as a "livening" agent.

These developments would have been insufficient to cope with the increasing demand for spirit had it not been for the introduction of cracking on a large scale. Cracking consists of subjecting heavy petroleum oils (usually of higher boiling point than kerosene) to heat and pressure, whereby compounds of lower molecular weight, and therefore lower boiling point are produced. Cracked spirit is of higher gravity than "straight" distilled spirit of the same boiling point. It is slightly disagreeable as regards smell, but otherwise a good fuel. Nearly all of the cracked spirit produced in the United States is taken up by the home market, the straight distilled spirit being exported. This process increases the possible yield of spirit from an average of 5 to 10% on the crude oil to 50 to 80% of the crude oil, which alters the entire aspect of the motor spirit problem.

In the present position there is little fear of a motor spirit shortage until there is a shortage of all petroleum products. The question now resolves itself into one of which product can stand the highest price. Probably lubricating oils and medicinal

products could command the highest prices. After these come motor spirit, then illuminating oils, then heavy oils for oil engines, and lastly furnace oils. Therefore the supply of furnace oils will suffer most by the introduction of cracking.

The majority of the people engaged in the petroleum industry do not expect any petrol shortage, at any rate for several years to come, in spite of the rapidly increasing demand.

The shale oil supply is less than ½ per cent. of the world's petroleum supply.

Benzol is at present the main petrol substitute. The principal sources of benzol are coal tar and coke oven gas. Gray and Mellanby estimate the possible yield in the United Kingdom, if all benzol were recovered from these sources, as follows :—

From coal tar..... 2 million gallons per annum.
From coke oven gas... 26 ,, ,, ,,

An enormous increase in the coal production does not appear probable in the near future, and therefore benzol is not likely to satisfy any large portion of the demand for motor spirit.

The actual production of benzol at the present time is about 10 per cent. of the quantity of petrol imported, and a large part of this is taken up by industries which are in a position to afford higher prices than are acceptable to motorists. At the best, benzol will only make a slight addition to the motor fuel supply. In the opinion of the speaker it will find its best utilisation in the form of mixtures.

The most promising source of petrol substitute at the present appears to be alcohol. Though it is low in heat value (12,697 B.Th.U. gross) it has the advantage of requiring a small amount of air for combustion, and it possesses a high ignition point, and is therefore able to withstand high compression pressures in internal combustion engines. In a suitably designed engine it yields about the same power per gallon as petrol. The possibilities of production of fuel alcohol in this country are not very promising. Dr. Ormandy, who has specialised on this subject for many years, informs me that he considers the most suitable method of preparation to be by the alcoholic fermentation of vegetable matter, and that the necessary vegetable substances can be most economically grown in tropical or subtropical countries. The calcium carbide process could not under existing conditions compete with the fermentation process as regards cost of production.

There is one more point to which I should like to call attention, and that concerns the methods used in valuing motor spirits. Hitherto motor spirit analysis has consisted of routine

laboratory tests. These are, however, quite inadequate for this object, and special tests are really required. Though for ordinary commercial purposes the distillation test is sufficiently accurate it is really only being used as a measure of the volatality, which is correctly measured by the vapour tension. Also in the past little notice has been taken of the importance of the ignition point, which is an indication of the maximum engine compression permissible, of which the thermal efficiency is a direct function.

The use of mixed fuels is yet in its infancy, but if maximum economy is to be obtained it will be necessary to employ a standard mixture as motor spirit for general use and to adjust the engine compressions to the corresponding permissible value. At present about 25 per cent. of the power available in benzol is wasted by the use of fuel in engines which are primarily designed for petrol.

Another advantage of the employment of mixtures is that usually two chemically different bodies of approximately the same vapour tension yield mixtures, the vapour tensions of which are higher than those of either constituent. The use of mixtures has already been initiated by the air forces, who have adopted a 20 per cent. benzol and 80 per cent. petrol mixture which possesses several advantages over normal petrol."

Ordinary Meeting, January 30th, 1920.

Mr. R. H. CLAYTON, B.Sc. (*Chairman*), in the Chair.

Dr. R. S. WILLOWS, M.A., opened a debate on **"Recent Work on Colloids."**

For the purpose of the address colloids were defined as matter in a fine state of subdivision, which consequently possesses a very large surface area. *E.g.*, if a cube of 1 cm. side is divided into cubes whose sides are one-millionth of a cm. the total surface is 60 sq. metres. With each sq. cm. of surface a definite amount of energy is known to be associated, and the difference between colloidal and other matter lies in the fact that the possible changes of this energy may entirely govern the physical and chemical behaviour of the colloid although they are negligible for matter in bulk. If the presence of a solute lowers the surface energy of a solvent, the solute will concentrate itself in the surface, thereby causing a maximum energy decrease. This excess concentration is called *adsorption*.

Instances of this adsorption effect which have important

applications are :—The clearing of turbid solutions by running them through an adsorbent such as charcoal; it is probably a first step in many dyeing operations and catalytic reactions; bacteria are removed from water by filtration through sand. McBain and others have shown in some instances that adsorption is followed by solution.

Sols are suspensions of very small particles in a suitable liquid. The particles have an electrical charge whose sign depends on the method of preparation, and not, as frequently stated, only on the chemical character of the substance. By the *X*-ray method they are found to be crystalline, although from their optical behaviour they are known to be nearly spherical in shape. Ellis has shown for emulsions that a *small* reduction in the electrical charge produces precipitation. He has also shown that surface tension has little effect in precipitation. Smoluchowski's theory of precipitation was explained.

The work of Thomson, Harkins and Langmuir on polarised molecules and their consequent effects (1) on the spreading of oil films on liquids, (2) on wetting of solids, and (3) on lubrication, were briefly described; as also Langmuir's determination of the length and section of molecules. Sulman's recent paper on mineral separation was mentioned.

Finally, the necessity for the co-operation of chemist and physicist was insisted on, and support was asked towards the establishment of a Chair of Colloids at Manchester University.

Special General Meeting, February 27th, 1920.

Mr. R. H. CLAYTON, B.Sc. (*Chairman*), in the Chair.

The proposed Rules of the Section were approved for submission to the Council of the Society for confirmation in accordance with No. 93 of the Articles of Association.

A copy of the Rules is available for inspection by any member at the Society's House.

Ordinary Meeting, February 27th, 1920.

Mr. R. H. CLAYTON, B.Sc. (*Chairman*), in the Chair.

Mr. JOHN ALLAN, F.C.S., opened a debate on "**Engineering as Applied to the Buildings and Plant in Chemical Works.**"

The expression "engineering" in the above sense involves knowledge much beyond that of an "astute fitter," and some of

it is of so particular a type that it might well be required of an exceptionally specialized civil engineer. As applied to buildings the nature of much of this knowledge is obvious, but again there is much that is not so apparent. Thus, for instance, knowledge as to the suitability of ground to carry the foundations of heavy buildings is obvious, but the effect of the soil upon metals which may be embedded in it or of diffused waste waters which may find their way into it, is not on the surface so apparently necessary as it actually is. In the construction of the buildings the ordinary attention to lighting, ventilation and so on is required, but consideration must also be given to the material of which the building and roofs are constructed. Ferro-concrete may be an ideal material for warehouses and the like, but in chemical plants in which the removal of vessels and pipe lines is frequent, it is objectionable on account of the great difficulty which it offers to such re-arrangements.

In the arrangement plant accessibility to all parts should receive first consideration. It is bad policy to bury tanks or pipe lines in the ground as leakages cannot be observed, and repairs are only possible after much labour and difficulty. Where it is necessary to have tanks or other portions of apparatus below the ground level they should be placed in a well with sufficient room for a workaman to move freely round them, observation then becomes possible.

Although hard and fast lines cannot be laid down in the matter, a study of the unit system of construction of plants is frequently profitable. This system enables a plant to be erected with the minimum cost in its erection so far as drawings, patterns, etc., are concerned, and further, if any portion of a plant consisting of a number of units breaks down, the effect upon the output of the whole plant is considerably less than when the construction is that of one or two very large sections. The adoption of standardization of construction materials would greatly facilitate the employment of the unit system, and even in other cases would simplify erection and extension. It would be necessary, however, before adopting standards to have the uses to which the materials are to be applied very carefully thought out, thus, whilst it is common to use earthenware drain pipes as conduits for gases in chemical works, these are invariably much too heavy for the work they have to do, with the result that supports are infinitely stronger than is necessary and much labour is involved in erecting or renewing the pipe lines. Such heavy pipes as are used in this country are rarely seen in continental works where light earthenware specially constructed for this purpose is employed.

The centralising of units of power, steam supply, etc., may be

economical or wasteful according to circumstances, and attention should be given wherever possible to the grouping of buildings housing particular operations, so that solid materials can be handled in buildings in proximity to each other and to the means of transport. Operations involving the use of steam should be carried on in buildings grouped round the central steam supply, such arrangements involving the minimum of losses which arise from radiation and other causes. A variety of points connected with the construction of drying plant, mixing apparatus, and the use of corrodible metals, were also gone into.

Annual General Meeting, April 30th, 1920.

Mr. R. H. CLAYTON, B.Sc. (*Chairman*), in the Chair.

The following Members were elected Officers of the Section and Members of the Committee for the ensuing year :—

Chairman : J. H. LESTER, M.Sc., F.I.C.
Vice-Chairman : R. H. CLAYTON, B.Sc.
Hon. Secretary : DAVID CARDWELL, M.Sc., F.I.C.

Other Members of the Committee : EDWARD ARDERN, D.Sc., F.I.C.; F. W. ATACK, B.Sc., M.Sc.Tech., F.I.C.; W. H. BENTLEY, D.Sc., F.C.S.; Professor ARTHUR LAPWORTH, D.Sc., F.R.S., F.I.C.; HAROLD MOORE, M.Sc.Tech., F.C.S., A.I.C.; Professor F. LEE PYMAN, D.Sc., Ph.D., F.I.C.; RONA ROBINSON, M.Sc., A.I.C.; LEONARD E. VLIES, F.C.S., F.I.C.; and T. R. WOLLASTON, M.I.Mech.E.

Ordinary Meeting, April 30th, 1920.

Mr. J. H. LESTER, M.Sc., F.I.C. (*Chairman*), in the Chair.

Dr. J. A. RUSSELL HENDERSON, F.C.S., read a paper entitled

"Alchemy and Chemistry amongst the Chinese."

Chinese alchemy is of great antiquity and is closely connected with the religion of Tao, which is indigenous to China and which dates back to the sixth century B.C., if not to the beginning of the Chinese race. The alchemists in China had the same objects in view as those in Europe at a much later time, viz., immortality and the transmutation of base metals into gold; their writings are obscure and they failed in their great

quest as did the alchemists of the west. However, the studies of the Chinese alchemists led to discoveries of practical importance in metallurgy, mineralogy and botany. China abounds in natural wealth and the Chinese have not been slow to avail themselves of this and to use it to their own advantage. The Chinese show great skill in metallurgy and in the manufacture of pigments, lacquers, porcelain, paper, etc. They very early discovered the explosive properties of gunpowder and made use of it in their wars.

The great mineral and vegetable wealth of China gives promise of a great chemical industry in the future. Methods at present in use are primitive, but modern methods and machinery are beginning to be employed and one can confidently look forward to the time when the latest methods will be used in the exploitation of the vast deposits of coal, iron and other metallic ores, and in the production of oils, essential oils and medicinal substances from vegetable sources.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Annual Report of the Council, April 1920.

The Society had at the beginning of the Session an ordinary membership of 143. Since then 200 new members have joined the Society (146 of these becoming members by the incorporation of the Manchester Chemical Club). Thirteen members have resigned, and four members (Mr. Marcus Allen, Mr. S. W. Gillett, Mr. A. J. King and Mr. Hermann Woolley) have died. There are, accordingly, at the end of the session, 326 ordinary members of the Society. The Society has also lost by death six honorary members, viz.: Professor W. G. Farlow, Professor Ernst Haeckel, Ph.D., Professor J. W. Hittorf, Sir Robert H. Inglis Palgrave, F.R.S., The Right Hon. Lord Rayleigh, O.M., M.A., D.C.L., Sc.D., F.R.S., and Dr. A. G. Vernon-Harcourt, M.A., F.R.S.

On the nomination of the Council, Mr. J. T. F. Bishop, Mr. W. S. Curphey, F.I.C., and Mr. C. W. Sutton, M.A., have been elected corresponding members of the Society.

Twenty-one papers have been read at the Society's meetings during the year; six shorter communications have also been made. In addition, five meetings and a soirée have been held by the Chemical Section.

Sir Henry A. Miers, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, was elected President in November, Professor G. Elliot Smith having been compelled to resign that office on his acceptance of the Professorship of Anatomy in the University of London. At the request of the Council, Professor F. E. Weiss, D.Sc., F.R.S., consented to act as Deputy Chairman when Sir Henry Miers could not attend the Society's meetings.

A new honorary office of Curator has been instituted, and the number of ordinary members of the Council increased from six to nine. Further, the Chairman and the Honorary Secretary of the Chemical Section have been made *ex-officio* members of the Council.

Society's Accounts.

The cash account of the Society is appended to this report. The net cash in hand at the close of the Session amounted to

£46 15s. 9d. On the other hand, the General Account is debtor to the Wilde Endowment Fund to the extent of £381 19s. 0d., to the Joule Memorial Fund £108 12s. 0d., to the Natural History Fund £162 3s. 3d., and, in addition, has a total net indebtedness of about £180.

Society's Library.

The Librarian reports that during the Session 453 volumes have been stamped, catalogued and pressmarked; 415 of these were serials. The total number of volumes catalogued to date is 38,560.

The additions to the library for the Session amounted to 627 volumes: 579 serials, and 48 separate works. The donations (exclusive of the usual exchanges) were 45 volumes; 3 volumes were purchased in addition to those regularly subscribed for. During the year 150 volumes have been bound in 102 covers. In the previous Session the corresponding numbers were 93 volumes in 92 covers.

The additions included "*Chemical Abstracts, Decennial Index Volumes* 1-10 (1907—1916), *Subject Index A—Z*," in two volumes (8vo., Easton, Pa., 1919), published by the American Chemical Society. The Society now subscribes to *Discovery* and *The Journal of Industrial and Engineering Chemistry*. The donations to the Society's Library during the Session include gifts of books by Mr. C. L. Barnes, Messrs. Edward Bennis & Co., Ltd., Mr. C. E. Stromeyer, the Trustees of the British Museum (Natural History), the Patent Office Library, London; the Director of the Geological Survey of India; the Académie Royale, Brussels; the Bataviaasch Genootschap van Kunsten en Wetenschappen, Batavia; the Yale University Press, New Haven, Conn., U.S.A.; the Bureau of American Ethnology, and the Smithsonian Institution, Washington; and the Department of Commerce, United States Coast and Geodetic Survey. The Optical Society, London (*Transactions*), and the Royal Aëronautical Society (*The Aëronautical Journal*), have been placed on the Society's list of exchanges.

The library continues to be satisfactorily used for reference purposes. 434 volumes have been borrowed from the library during the past year. The number of books borrowed during the previous year was 283 and during 1917-18, 280.

The publication of the Society's *Memoirs and Proceedings* has been continued under the supervision of the Editorial Committee.

Donations.

The Society has received from Mr. Henry Boddington, J.P., of Wilmslow, a valuable etched portrait of Henry D. Pochin, D.Sc., J.P., Mayor of Salford 1866-68.

Other gifts to the Society during the year include a barometer, which belonged to the late Dr. Henry Wilde, presented by the University of Oxford; a photograph of Dr. Wilde, presented by Professor H. B. Dixon, M.A., Ph.D., F.R.S.; and 32 volumes of the Society's *Memoirs and Proceedings,* presented by Mr. John Boyd.

Dalton Medal.

A Dalton Medal (struck in 1864) was unanimously awarded by the Council to Sir Ernest Rutherford, M.A., D.Sc., F.R.S., "in recognition of his brilliant researches in Manchester on the constitution of the atom."

Formation of Chemical Section.

A Chemical Section of the Society was formed and elected the following Officers:—Chairman, Mr. R. H. Clayton; Treasurer, Mr. J. H. Lester; Secretary, Mr. F. W. Atack. Meetings of the Section have been held monthly. On Friday, March 26th, 1920, the Section held a Soirée by invitation of Mr. R. H. Clayton.

Society's House.

In accordance with discussions which have taken place during the last twelve months at meetings of the Society, the Council have carefully considered what steps might be taken to extend the utility of the Society as a centre for literary and scientific intercourse in the Manchester district. Several advances have been made already; for example, a Chemical Section has been formed, and in addition the Manchester Astronomical Society and the Manchester Microscopical Society are holding their meetings in the Society's house. Several meetings of other scientific bodies have been held in the rooms, and informal communications have been received from others with reference to similar privileges.

A recent re-arrangement of two of the Society's rooms has made it possible to provide a comfortable room, supplied with writing-table and current copies of the scientific journals, for the convenience of members. The opening of the premises in the evenings has already been appreciated by a number of members, especially those who are unable to make use of the

Society's room during the daytime. The Society's House is now open to members from 9.30 a.m. to 9,30 p.m. on every weekday except Saturdays, when it is open from 9.30 a.m. to 2 p.m.

Building Extensions and Alterations.

An appeal for funds has been issued to members of the Society in which attention was drawn to the following points :

The Society's house contains no room capable of accommodating more than about one hundred persons, a number which is already exceeded at many of the meetings of certain local societies, and it is clear that if the Society's house is to become the meeting place for local literary and scientific societies, and indeed even to provide for the needs of its own rapidly increasing membership, the premises must be extended.

Fortunately, there exists a small plot of land behind the Society's house which would be suitable for extension, and which has been offered to the Society on acceptable terms. The Council have therefore asked the advice of an architect with a view to discovering whether their needs could be met by extension on this site, with some minor structural alterations to the present building. Plans have been prepared, and a copy of them circulated for the consideration of members. The extension and alterations will provide, amongst other benefits, the following :—

(1) A library and meeting room capable of seating some two hundred persons.
(2) A smaller lecture room for smaller meetings.
(3) Committee room and ladies' common room.
(4) Extended accommodation for books.
(5) Improved lavatory accommodation.

At the same time, there will be no interference with the leading features of the existing house with their historical associations, such as the room used by John Dalton.

It is hoped that members of the Society will appreciate the advantages of the scheme, for its successful consummation will require their active individual collaboration. The cost is estimated at about £8,000, and it is obviously necessary that members of the Society should give the scheme their fullest financial support. For this purpose £1,046 17s. 6d. has already been promised, by 53 members, towards the proposed building extensions and alterations.

NOTE.—The Treasurer's Accounts for the Session 1919-1920 *have been endorsed as follows* :

April 9th, 1920. Audited and found correst.

We have also seen, at this date, the Certificates of the following Stocks held in the name of the Society :—£1,225 Great Western Railway Company 5% Consolidated Preference Stock, Nos. 12,293, 12,294, and 12,323; £7,500 Gas Light and Coke Company Ordinary Stock (No. 8/1960); £100 East India Railway Company 4% Annuity Stock (No. 4032); and the deeds of the Natural History Fund, of the Wilde Endowment Fund, those conveying the land on which the Society's premises stand, and the Declarations of Trust.

Leases and Conveyances dated as follows :—

22nd Sept., 1797.
23rd Sept., 1797.
25th Dec., 1799.
25th Dec., 1799.
23rd Dec., 1820.
23rd Dec., 1820.

Declarations of Trust :—

24th June, 1801.
23rd Dec., 1820.
8th Jan., 1878.

Appointment of New Trustees :—

30th April, 1851.

We have also seen Bankers' acknowledgment of the investment of £300 in the 5% War Loan :—2 Bonds for £100 each, Nos. 71827 and 366270; and 2 Bonds for £50, Nos. 131577 and 31358.

We have also verified the balances of the various accounts with the bankers' pass books.

(*Signed*) { J. WILFRID JACKSON.
R. S. WILLOWS.

Dr. *W. Henry Todd, Treasurer, in Account with th*

		£	s.	d.	£	s.	d.
To Balance, 1st April, 1919...					25	10	
To Members' Subscriptions :—							
Half Subscriptions,	1918-19, 1 at £1 1s. od.	1	1	0			
„	1919-20, 13 „ „	13	13	0			
„	1920-21, 1 „ „	1	1	0			
Subscriptions :—	1915-16, 1 at £2 2s. od.	2	2	0			
„	1916-17, 1 „ „	2	2	0			
„	1917-18, 3 „ „	6	6	0			
„	1918-19, 7 „ „	14	14	0			
„	1919-20, 128 „ „	268	16	0			
„	1920-21, 1 „ „	2	2	0			
„	1919-20, 10 at £1 1s. od. (½ year)	10	10	0	322	7	
To Life Composition Fee					26	5	
To Manchester Chemical Club :—							
146 Members at £2. 2s. od.					306	12	
To Sale of Publications :—							
Memoirs and Proceedings		22	18	1			
Catalogues		0	18	6	23	16	
To W. R. Halkyard, Donation towards Plates ...					60	0	
To Henry Wilde's Executors, Cost of Setting up Paper					3	0	
To Transfers from Wilde Endowment Fund :—							
Rent of Rooms		50	0	0			
Entrance Fees		12	12	0			
Half Subscriptions		17	17	0	80	9	
To Dividends :—							
Natural History Fund		42	17	6			
Joule Memorial Fund		15	2	8			
Wilde Endowment Fund		7	0	0	65	0	
To Special Donations :—							
R. H. Clayton		100	0	0			
F. W. Atack		20	0	0	120	0	
To Soirée Donations :—							
William Thomson		15	0	0			
Council		9	7	0	24	7	
To Loans from Wilde Endowment Fund					381	19	
To Bank Interest					0	19	
To Expenses of Meetings :—							
Manchester Microscopical Society		5	0	0			
„ Chemical Club		4	10	0			
„ Section, Institute of Chemistry ...		4	12	9	14	2	
To Wilde Portraits					6	6	
To National Health Insurance Act deductions ...					1	16	1
					£1.462	10	

ND PHILOSOPHICAL SOCIETY.

ciety, from 1st April, 1919, to 31st March, 1920. **Cr.**

	£ s. d.	£ s. d.
Overdraft at Williams Deacon's Bank, 1st April, 1919 ..		164 14 10
Charges on Property :—		
Chief Rent	9 0 10	
Income Tax and Inhabited House Duty	3 17 4	
Insurance against Fire	11 0 0	
		23 18 2
House Expenditure :—		
Coal, Gas, Electric Light, Water, etc.	47 10 1	
Tea, Coffee, etc., at Meetings	40 0 1½	
Cleaning, Washing, etc....	8 10 11	
Replacements	15 3 3½	
Repairs, etc.	22 3 7½	
Carpet Cleaned, etc.	4 7 9	
Chairs Re-seated	8 8 0	
Clock Cleaned	0 15 0	
Busts Cleaned	4 0 0	
Common Room Decorated	39 10 0	
Blinds	4 6 0	
Wilde Photos, etc.	10 3 0	
Herbarium Cabinet...	7 7 6	
		212 5 3½
Administrative Charges :—		
Assistant Secretary's Salary	83 6 8	
Acting „ „	25 0 0	
Caretaker and Housekeeper...	97 10 0	
Servant	6 10 0	
Extra Attendance at Meetings	20 7 6	
Postages, Carriage of Parcels, " Memoirs " ...	37 9 5½	
Stationery, Cheques, Receipts, Engrossing etc.	36 5 7	
Insurance against Liability	1 11 2	
National Health Insurance Stamps	3 9 4	
Miscellaneous Expenses	3 10 9	
		315 0 5½
Publishing :—		
Printing " Memoirs and Proceedings," and Illustrations, Circulars, etc.		320 16 11
Library :—		
Periodicals (except those charged to Natural History Fund)		19 3 8
Soirée Expenses		31 5 7
Institute of Chemistry Meeting		4 12 9
Setting up Wilde Paper		3 0 0
Manchester Chemical Club. Purchase of Stock		264 1 3
Bank Interest on Overdraft etc.		4 18 6
Natural History Fund :—		
(Items shown in Balance Sheet of this Fund)		26 13 9
Wilde Endowment Fund :—		
Dividend Refunded (War Loan)		7 0 0
Balance at Williams Deacon's Bank, 1st April, 1920	54 19 6	
Balance in Treasurer's Hands	10 0 0	
		64 19 6
		£1.462 10 8

JOULE MEMORIAL FUND, 1919-1920. (Included in the General Account, above.)

	£	s.	d.		£	s.	d.
To Balance, 1st April, 1919	93	9	4	By Balance, 1st April, 1920	108	12	0
To Dividends :—							
Dividend on £100 East India Railway Company's 4% Annuity Stock 6 7 8							
Interest on £250 5% War Loan Stock 8 15 0							
	15	2	8				
	£108	12	0		£108	12	0

NATURAL HISTORY FUND, 1919-1920. (Included in the General Account, above.)

	£	s.	d.		£	s.	d.
To Balance, 1st April, 1919	145	19	6	By Natural History Periodicals	15	2	6
To Dividends on £1,225 Great Western Railway Company's Stock	42	17	6	By Subscriptions :—			
				Entomological Society, 1919 and 1920 ... ... 2 2 0			
				Lancashire and Cheshire Fauna Committee, 1919... 1 1 0			
				Paleontographical Society, 1917 ... ... 1 1 0			
				Ray Society, 1920 ... ... 1 1 0			
					5	5	0
				By Binding Natural History Periodicals	6	6	3
				By Balance, 1st April, 1920	162	3	3
	£188	17	0		£188	17	0

WILDE ENDOWMENT FUND, 1919-1920.

	£	s.	d.		£	s.	d.
To Balance, 1st April, 1919	171	0	4	By Assistant Secretary's Salary	137	10	0
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	157	10	0	By Acting „ „	12	10	0
To Interest on War Loan Stock :—				By Maintenance of Society's Library :—			
On £350 for 6 months 6 2 6				Binding Books	24	19	9
On £50 for 6 months 0 17 6				By Loan to Society's Funds :—			
	7	0	0	Sale of £300 War Loan Stock 281 19 0			
To Sale of £300 War Loan Stock	281	19	0	Printing of Memoirs 100 0 0			
					381	19	0
To Bank Interest	1	18	10	By Transfer to Society's Funds :—			
To Overdraft at Williams Deacon's Bank, 1st April, 1920 ...	18	3	9	Rent of Rooms 50 0 0			
				Entrance Fees 12 12 0			
				Half Subscriptions 17 17 0			
					80	9	0
				By Cheque Book	0	4	2
	£637	11	11		£637	11	11

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1919-20.

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Assistant Secretary and Librarian.

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THE WILDE LECTURES.

1897. (July 2.) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S. (28 pp.)

1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S. (46 pp.)

1899. (Mar. 28.) "The newly discovered Elements; and their relation to the Kinetic Theory of Gases." By Professor WILLIAM RAMSAY, F.R.S. (19 pp.)

1900. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S. (26 pp.)

1901. (April 22.) "Sur la Flore du Corps Humain." By Dr. ELIE METSCHNIKOFF, For.Mem.R.S. (38 pp.)

1902. (Feb. 25.) "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion." By Dr. HENRY WILDE, F.R.S. (34 pp., 3 pls.)

1903. (May 19.) "The Atomic Theory." By Professor F. W. CLARKE, D.Sc. (32 pp.)

1904. (Feb. 23.) "The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A. (42 pp.)

1905. (Feb. 28.) "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." Dr D. H. SCOTT, F.R.S. (32 pp., 3 pls.)

1906. (March 20.) "Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S. (32 pp.)

1907. (Feb. 18.) "The Structure of Metals." By Dr. J. A. EWING, F.R.S., M.Inst.C.E. (20 pp., 5 pls., 5 text-figs.)

1908. (March 3.) "On the Physical Aspect of the Atomic Theory." By Professor J. LARMOR, Sec.R.S. (54 pp.)

1909. (March 9.) "On the Influence of Moisture on Chemical Change in Gases." By Dr. H. BRERETON BAKER, F.R.S. (8 pp.)

1910. (March 22.) "Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

SPECIAL LECTURES.

1913. (March 4.) "The Plant and the Soil." By A. D. HALL, M.A., F.R.S.

1914. (March 18.) "Crystalline Structure as revealed by *X*-rays." By Professor W. H. BRAGG, M.A., F.R.S.

1915. (May 4.) "The Place of Science in History." By Professor JULIUS MACLEOD, D.Sc.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.

1900. Sir HENRY E. ROSCOE, F.R.S.

1903. Prof. OSBORNE REYNOLDS, LL.D., F.R.S.

1919. Prof. Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S.

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1787-1789.	JAMES MASSEY.
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1809.	*JOHN HULL, M.D., F.L.S.
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1886.	ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.

* Elected April 28th; resigned office May 5th.

Date of Election.

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1888-1889. OSBORNE REYNOLDS, LL.D., F.R.S.
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1892-1893. ARTHUR SCHUSTER, Ph.D., F.R.S.
1894-1896. HENRY WILDE, D.C.L., F.R.S.
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VOL. 64 : PART I.

MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY & PHILOSOPHICAL SOCIETY, 1919-20.

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MANCHESTER :
36, GEORGE STREET.

Price : Four Shillings.

February 28th, 1921.

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MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER

LITERARY & PHILOSOPHICAL

SOCIETY, 1919-20.

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